



CHARLES RIVER DAM AT SOUTH NATICK

PHASE I INSPECTION/EVALUATION REPORT



Dam Name: Charles River Dam at South Natick

State Dam ID#: 4-9-198-1

NID ID#: MA00341

Owner: Town of Natick

Town: Natick, MA

Consultant: GZA GeoEnvironmental, Inc.

Date of Inspection: October 13, 2017



Proactive by Design

GEOTECHNICAL
ENVIRONMENTAL
ECOLOGICAL
WATER
CONSTRUCTION
MANAGEMENT

249 Vanderbilt Avenue
Norwood, MA 02062
T: 781.278.3700
F: 781.278.5701
F: 781.278.5702
www.gza.com



November 30, 2017
GZA File No. 01.0019114.70

Mr. William McDowell, P.E.
Town Engineer, Town of Natick
Dept. of Public Works
75 West Street
Natick, Massachusetts 01240

Re: Phase I Inspection/Evaluation Report
Charles River Dam at South Natick
NID # MA 00341
Middlesex County

Dear Mr. McDowell:


On behalf of the Town of Natick, GZA GeoEnvironmental, Inc. (GZA) has completed our visual inspection of the Charles River Dam located off Mill Lane in South Natick, Massachusetts. The site visit was conducted on October 13, 2017. The purpose of our efforts was to provide the Massachusetts Department of Conservation and Recreation, Office of Dam Safety (DCR-ODS) with an updated, formal Phase I inspection in order for the Town of Natick to maintain compliance with 302 CMR 10.00 Dam Safety Regulations, pertaining to inspection frequency and in accordance with DCR-ODS' September 18, 2017 Order to Conduct a Phase I Dam Safety Inspection with report filed no later than January 18, 2018. This updates GZA's Phase I inspection conducted in 2015.

Based on our inspection, the dam is currently in **FAIR** condition, in our opinion. A further discussion of our evaluation and recommended actions items are presented in the Inspection/Evaluation Report. In addition to an electronic copy transmitted to you, one hard copy of the report and one electronic copy of the report and checklist has been provided on your behalf to the DCR-ODS. In accordance with DCR-ODS format requirements, the report also includes a: (a) Dam Evaluation Summary Detail Sheet (b) completed checklist; (c) field sketch; and (d) selected photographs with captions. Our services and report are subject to the Limitations found in **Appendix A**.

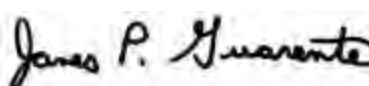
Please contact the undersigned if you have any questions or comments regarding the content of this Inspection/Evaluation Report.

Sincerely,
GZA GeoEnvironmental, Inc.


Maha Jarrar
Project Engineer


Peter H. Baril, P.E.
Principal-in-Charge


Charles B. Nourse, P.E.
Project Manager


James P. Guarente, P.E.
Consultant/Reviewer



EXECUTIVE SUMMARY

This report summarizes the results of a Phase I visual dam inspection conducted by GZA GeoEnvironmental, Inc. (GZA) on October 13, 2017 for the Charles River Dam, located in South Natick, Massachusetts. The dam is owned and operated by the Town of Natick. In general, the Charles River Dam at South Natick is judged to be **FAIR** condition. There has been no substantial change from the previous inspection in 2015.

The last formal Phase I inspection of the Charles River Dam was performed by GZA on September 9, 2015. In 2009, GZA performed a Phase II evaluation of the dam which included detailed Hydrologic and Hydraulic (H&H) Analyses, embankment slope stability and seepage analyses, an underwater inspection of upstream portions of the concrete spillway/training walls, and a condition/functionality assessment of the existing low-level outlet gate works. We also developed recommendations and preliminary cost estimates for selected remedial repair alternatives to address deficiencies identified during our investigation and analyses.

The following is a summary of dam safety issues noted during this recent inspection:

1. Mature trees and shrubs throughout earth embankment on right side of spillway;
2. Minor erosion at top of earth embankment and downstream embankment due to pedestrian traffic;
3. Minor leakage through blocked, abandoned outlet at downstream toe of earth embankment near the right abutment;
4. Minor scarping and some erosion at waterline at upstream slope of earth embankment;
5. Deteriorated cast-in-place concrete with cracked, spalled and misaligned sections associated with the low training wall upstream of the left spillway abutment;
6. Some loose and missing stones and loose/missing mortar at stone masonry spillway training walls on both left and right sides of the spillway discharge channel (Charles River);
7. New tree/vegetation growth re-establishing within joints of left and right stone masonry spillway training wall;
8. Slight lean toward the river of the low retaining wall on right side of the spillway discharge area and loss of ground/ground subsidence behind wall;
9. Deteriorated cast-in-place concrete with cracked, chipped, spalled sections associated with the low-level outlet slide gate structure on the right spillway abutment;
10. Erosion/minor void in concrete along left side of outside concrete wall of outlet structure at waterline; and
11. Inoperable slide gates at the outlet works.

GZA recommends that the Town of Natick perform the following:

Studies and Analyses:

1. Prepare written operations and maintenance plan;
2. Continue to review and update the existing Emergency Action Plan (EAP) annually to update contact names/numbers, etc., as appropriate. The Town has handled this annual update in the past;



3. Continue monitoring the condition of stone masonry and concrete spillway training walls;
4. Continue monitoring the condition of concrete associated with slide gate outlet structure;
5. Continue monitoring the leakage at the blocked former outlet for increases in flow rate and clarity of flow; and
6. Conduct a detailed inspection of the downstream face of spillway. It is envisioned that this could be prudently accomplished after the slide gates have been replaced at which time they could be opened slightly to lower the water level enough such that the downstream side of the spillway is clearly exposed. It is noted that flow over the spillway during this (2017) inspection was low which allowed for an improved level of inspection of this area.

Maintenance and Minor Repairs:

1. Maintain a program of brush removal and grass trimming at the earthen embankment.
2. Remove vegetation which is beginning to re-establish within joints of left stone masonry spillway training wall including, to the extent practicable, removal of associated stumps and root balls.

Remedial Measures:

The following more comprehensive remedial measures were formulated based partly on the results of GZA's 2009 Phase II evaluation and include actions to bring the structure into compliance with Massachusetts Dam Safety Regulations and current engineering practice.

1. Clear trees and woody vegetation from the embankments, crest and downstream toe area. Additionally, remove all roots/root balls associated with trees and vegetation and backfill resulting voids with compacted sand/gravel;
2. Re-surface the upstream embankment with stone rip-rap protection;
3. Re-grade the downstream embankment to a uniform 3H:1V slope. Place proprietary turf reinforcement matting over the crest and downstream slope to address potential for crest overtopping via wave action and erosion of the downstream slope via high backwater conditions;
4. Execute a complete replacement of both gates coupled with appropriate re-configuration/restoration of the concrete superstructure surrounding the gate openings; and
5. Repair/re-build the upstream and downstream training wall portions of the spillway discharge area which exhibit deteriorated concrete, missing stones/mortar, leaning and related deficiencies.

A preliminary opinion of probable construction cost for the repairs and remedial measures recommended above is approximately **\$1,270,000 to \$1,570,000**. The Town continues the process of refining costs estimated to effect implementation of the preferred repair alternatives as outlined in the 2009 Phase II study. Funds to repair deficiencies are a part of the Department of Works annual Capital Planning/Budget request process. Additionally, the Town has in the past applied to the Dam and Seawall Repair or Removal Program which offers financial resources to qualified applicants for projects that share the mission to enhance, preserve, and protect the natural resources and the scenic, historic and aesthetic qualities of the Commonwealth of Massachusetts. Unfortunately, they have been unsuccessful in securing any funding through this program, but plan on re-applying during future open application periods.

Dam Evaluation Summary Detail Sheet

1. NID ID:	MA00341	4. Inspection Date:	October 13, 2017
2. Dam Name:	Charles River Dam at South Natick	5. Last Insp. Date:	Last Phase I on 9/9/2015; Phase II in 2009.
3. Dam Location:	Natick, MA	6. Next Inspection:	October 13, 2019
7. Inspector:	Charles B. Nourse, P.E.		
8. Consultant:	GZA GeoEnvironmental, Inc.		
9. Hazard Code:	High	9a. Is Hazard Code Change Requested?:	No
10. Insp. Frequency:	2 Years	11. Overall Physical Condition of Dam:	FAIR
12. Spillway Capacity (% SDF)	>100% SDF w/ no actions by Caretaker		
E1. Design Methodology:	4	E7. Low-Level Discharge Capacity:	2
E2. Level of Maintenance:	3	E8. Low-Level Outlet Physical Condition:	1
E3. Emergency Action Plan:	5	E9. Spillway Design Flood Capacity:	5
E4. Embankment Seepage:	5	E10. Overall Physical Condition of the Dam:	3
E5. Embankment Condition:	2 See Note b.	E11. Estimated Repair Cost:	1,270K to 1,570K
E6. Concrete Condition:	3		

Evaluation Description

E1: DESIGN METHODOLOGY

1. Unknown Design – no design records available
2. No design or post-design analyses
3. No analyses, but dam features appear suitable
4. Design or post design analysis show dam meets most criteria
5. State of the art design – design records available & dam meets all criteria

E2: LEVEL OF MAINTENANCE

1. Dam in disrepair, no evidence of maintenance, no O&M manual
2. Dam in poor level of upkeep, very little maintenance, no O&M manual
3. Dam in fair level of upkeep, some maintenance and standard procedures
4. Adequate level of maintenance and standard procedures
5. Dam well maintained, detailed maintenance plan that is executed

E3: EMERGENCY ACTION PLAN

1. No plan or idea of what to do in the event of an emergency
2. Some idea but no written plan
3. No formal plan but well thought out
4. Available written plan that needs updating
5. Detailed, updated written plan available and filed with MADCR, annual training

E4: SEEPAGE (Embankments, Foundations, & Abutments)

1. Severe piping and/or seepage with no monitoring
2. Evidence of monitored piping and seepage
3. No piping but uncontrolled seepage
4. Minor seepage or high volumes of seepage with filtered collection
5. No seepage or minor seepage with filtered collection

E5: EMBANKMENT CONDITION (See Note 1)

1. Severe erosion and/or large trees
2. Significant erosion or significant woody vegetation
3. Brush and exposed embankment soils, or moderate erosion
4. Unmaintained grass, rodent activity and maintainable erosion
5. Well maintained healthy uniform grass cover

E6: CONCRETE CONDITION (See Note 2)

1. Major cracks, misalignment, discontinuities causing leaks, seepage or stability concerns
2. Cracks with misalignment inclusive of transverse cracks with no misalignment but with potential for significant structural degradation
3. Significant longitudinal cracking and minor transverse cracking
4. Spalling and minor surface cracking
5. No apparent deficiencies

E7: LOW-LEVEL OUTLET DISCHARGE CAPACITY

1. No low level outlet, no provisions (e.g. pumps, siphons) for emptying pond
2. No operable outlet, plans for emptying pond, but no equipment
3. Outlet with insufficient drawdown capacity, pumping equipment available
4. Operable gate with sufficient drawdown capacity
5. Operable gate with capacity greater than necessary

E8: LOW-LEVEL OUTLET PHYSICAL CONDITION

1. Outlet inoperative needs replacement, non-existent or inaccessible
2. Outlet inoperative needs repair
3. Outlet operable but needs repair
4. Outlet operable but needs maintenance
5. Outlet and operator operable and well maintained

E9: SPILLWAY DESIGN FLOOD CAPACITY

1. 0 - 50% of the SDF or unknown
2. 50-90% of the SDF
3. 90 - 100% of the SDF
4. >100% of the SDF with actions required by caretaker (e.g. open outlet)
5. >100% of the SDF with no actions required by caretaker

E10: OVERALL PHYSICAL CONDITION OF DAM

1. UNSAFE – Major structural, operational, and maintenance deficiencies exist under normal operating conditions
2. POOR - Significant structural, operation and maintenance deficiencies are clearly recognized under normal loading conditions
3. FAIR - Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters
4. SATISFACTORY - Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.
5. GOOD - No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF

E11: ESTIMATED REPAIR COST

Estimation of the total cost to address all identified structural, operational, maintenance deficiencies. Cost shall be developed utilizing standard estimating guides and procedures

Changes/Deviations to Database Information since Last Inspection

- a). Emergency Action Plan updated by GZA GeoEnvironmental, Inc., in 2012.
- b). The mature trees scattered over the crest and downstream embankment should be removed. Given the width of the dam, it does not appear that there would be an imminent stability issue if one the trees were to overtop. Thus overall condition is considered Fair.



PREFACE

The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigations and analyses involving topographic mapping, subsurface investigations, testing and detailed computational evaluations are beyond the scope of this report.

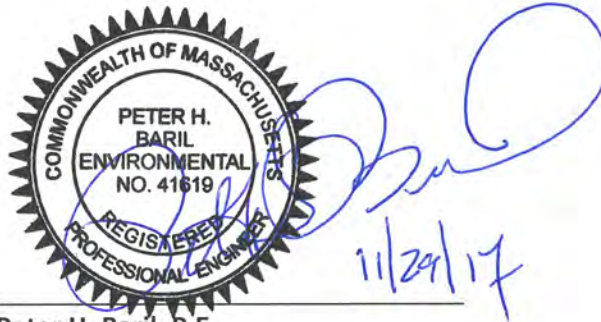
In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection, along with data available to the inspection team. In cases where an impoundment is lowered or drained prior to inspection, such action, while improving the stability and safety of the dams, removes the normal load on the structure and may obscure certain conditions, which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dams at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.



Charles B. Nourse, P.E.
Massachusetts License No.: 50278

Project Manager
GZA GeoEnvironmental, Inc.



Peter H. Baril, P.E.
Massachusetts License No.: 41619

Principal
GZA GeoEnvironmental, Inc.



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Figure 3:	Drainage Area
Figure 4:	Dam and Downstream Area
Figure 5:	Site Sketch with Photo Locations

APPENDICES

Appendix A:	Limitations
Appendix B:	Photographs
Appendix C:	Inspection Checklist
Appendix D:	Previous Reports and References
Appendix E:	Definitions
Appendix F:	Historic Documentation



1.0 DESCRIPTION OF PROJECT

1.1 GENERAL

1.1.1 Authority

The Town of Natick has retained GZA GeoEnvironmental, Inc. (GZA) to perform a visual inspection and develop a report of conditions for the Charles River Dam at South Natick, Massachusetts. GZA's proposal to conduct the work was signed and authorized by the Town of Natick on September 25, 2017. This inspection and report were performed in accordance with MGL Chapter 253, Sections 44-50 of the Massachusetts General Laws as amended by Chapter 330 of the Acts of 2002. This report is subject to the Limitations in **Appendix A**.

1.1.2 Purpose of Work

The purpose of this investigation is to inspect and evaluate the present condition of the dam and appurtenant structures in accordance with 302 CMR 10.07 to provide information that will assist in both prioritizing dam repair needs and planning/conducting maintenance and operation.

The investigation is divided into four parts: 1) obtain and review available reports, investigations, and data previously submitted to the owner pertaining to the dam and appurtenant structures; 2) perform a visual inspection of the site; 3) evaluate the status of an emergency action plan for the site and; 4) prepare and submit a final report presenting the evaluation of the structure, including recommendations and remedial actions, and opinion of probable costs.

1.1.3 Definitions

To provide the reader with a better understanding of the report, definitions of commonly used terms associated with dams are provided in **Appendix E**. Many of these terms may be included in this report. The terms are presented under common categories associated with dams which include: 1) orientation; 2) dam components; 3) size classification; 4) hazard classification; 5) general; and 6) condition rating.

1.2 DESCRIPTION OF PROJECT

1.2.1 Location

Charles River Dam at South Natick is located on the Charles River, off of Mill Lane, in the Town of Natick, Middlesex County, Massachusetts. Pleasant Street is approximately 170 feet downstream of the dam. Access to left abutment and spillway training walls is adjacent to Mill Lane. Access to the earthen embankment portion and right spillway training walls is adjacent to Pleasant Street. A locus map and an aerial photograph of the site are provided in **Figure 1** and **Figure 2** respectively. The Dam can be located at:

Latitude 42.271555°N

Longitude -71.315818°W.



1.2.2 Owner/Caretaker

The dam is owned and maintained by the Town of Natick. Mr. William McDowell P.E., Town Engineer for the Town of Natick, acts as the primary caretaker for the dam.

	Dam Owner	Dam Caretaker
Name	Town of Natick, Massachusetts	Town of Natick, Massachusetts
Mailing Address	75 West Street	75 West Street
Town	Natick, MA 01760	Natick, MA 01760
Daytime Phone	508-647-6551	508-647-6551
Emergency Phone	508-647-6550	508-647-6550
Email Address	wmcdowell@natickma.org	wmcdowell@natickma.org

1.2.3 Purpose of the Dam

The dam currently impounds the Charles River and is used for recreational purposes. A small park, with benches and picnic tables, is located on either side of the dam.

1.2.4 Description of the Dam and Appurtenances

The Charles River Dam consists of a 15-foot-high earthen embankment dam on the right bank of the river with an approximately 12-foot-high run-of-the-river concrete ogee-shaped, curved spillway left of the embankment. The embankment portion of the dam is about 200 feet long and its top width is generally about 20 to 30 feet wide. The upstream and downstream embankment slopes are vegetated, including mature trees, and slope at about three-foot horizontal to one-foot vertical (3H:1V). A vertical, mortared stone masonry wall comprises portions of the downstream face of the embankment adjacent to the spillway's left abutment.

The spillway is an approximately 130-foot long uncontrolled, concrete ogee weir and has a curved (upstream) horizontal alignment. The spillway has stone masonry training walls upstream and downstream. Flow is conveyed beneath Pleasant Street about 170 feet downstream via a series of stone masonry arch openings. The remnants of a Denil-type concrete fishway are located at the right side of the spillway.

A concrete low-level outlet structure is located at the spillway's right abutment. The outlet structure contains two approximately 4-foot-wide by 6-foot-high spigot type, cast iron slide gates. The Rodney Hunt gate operators are located atop the concrete outlet structure.

Remnants of a separate low-level sluiceway outlet are located at the downstream toe of the earth embankment portion of the dam approximately 150 feet from the right abutment. The outlet headwall is stone masonry, and has been plugged. According to the 1934 Fay, Spofford & Thorndike, Inc., (FST) Drawings made available to GZA, this abandoned outlet consisted of a 12-inch diameter cast iron pipe encased in 4-inch thick concrete that discharged to a 5-foot wide weir chamber. An apparently abandoned sluiceway channel from this outlet meanders generally parallel to Pleasant Street along the toe of the dam to the main river channel. During periods of elevated flow, the channel is filled with backwater from the river. No intake structure was observable upstream of this outlet.

The grounds on the dam to the right of the spillway and adjacent to the dam left of the spillway are publicly accessible park areas which appear to be well-used. Park benches are present on the left abutment and benches and picnic tables are present on the top of the earth embankment portion of the dam, right of the spillway.



1.2.5 Operations and Maintenance

The dam is operated and maintained by the Town of Natick. There is no formal operations and maintenance plan for the dam. Mr. William McDowell, P.E., Natick Town Engineer has supervisory responsibility for operations and maintenance. According to drawings and correspondence in the Town's files including those obtained by GZA from FST, the dam underwent a major reconstruction to its present configuration in/about 1934. Minor repairs were also performed by the Town to re-build and backfill a hole which had formed in the left downstream lower training wall of the dam in 2010.

1.2.6 DCR Size Classification

Charles River Dam at South Natick has a maximum structural height of approximately 15 feet and a maximum storage capacity (top of embankment dam) of approximately 500 acre-feet. Therefore, in accordance with Department of Conservation and Recreation Office of Dam Safety classification, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00 as amended by Chapter 330 of the Acts of 2002, Charles River Dam at South Natick is an **Intermediate** size structure due to its maximum storage capacity being less than 1000 acre-feet but greater than 50 acre-feet. Refer to **Appendix E** for definitions of height of dam and storage.

1.2.7 DCR Hazard Potential Classification

Charles River Dam at South Natick is located in an urbanized area of the Town of Natick. Pleasant Street is located about 170 feet downstream of the dam. Several residential structures are also located downstream of the dam. A dam failure will likely cause loss of life and serious damage to homes, industrial or commercial facilities, important public utilities and buildings and main arterial roadways. Therefore, in accordance with Department of Conservation and Recreation classification procedures, under Commonwealth of Massachusetts dam safety rules and regulations stated in 302 CMR 10.00 as amended by Chapter 330 of the Acts of 2002, Charles River Dam at South Natick is classified as a **High** (Class I) hazard potential dam. GZA concurs with this classification.

1.3 PERTINENT ENGINEERING DATA

1.3.1 Drainage Area

The drainage area for Charles River Dam at South Natick is approximately 165 square miles and extends through the communities of Sherborn, Holliston, Millis, Medway, Milford, Franklin and parts of Medfield, Wrentham, Bellingham, Norfolk, Hopedale and Walpole. The drainage area drains mild to moderately sloped areas (refer to **Figure 3**).

1.3.2 Reservoir

See **Table 1.1** for data about normal, maximum, and spillway design flood (SDF) pools.

1.3.3 Discharges at the Dam Site

There were no records available to GZA regarding discharges at the dam site. However, as part of our Hydrologic and Hydraulic Analyses for this dam (conducted in 2009), we evaluated data from United States Geological Survey (USGS) Stream Gages on the Charles River which are in the vicinity (upstream and downstream) of the dam. Refer to the Hydrologic/Hydraulic Data in Section 2.5, below, for additional information.



1.3.4 General Elevations

The following elevations in feet (referenced to National Geodetic Vertical Datum - 1929) are from the Phase II evaluation topographic survey performed at the dam in January of 2009 by Norwood Engineering Company, Inc.

A. Top of Dam (Right Embankment Portion)	116.0 feet ¹
B. Spillway Design Flood Pool	115.1 feet (GZA Phase II)
C. Normal Pool	110.6 feet
D. Spillway Crest	110.6 feet
E. Upstream Water at during Inspection	±110.7 feet
F. Streambed at Toe of the Dam	102.7 feet
G. Low Point along Toe of the Dam	±102.0 feet

1.3.5 Main Spillway Data

A. Type	Ogee shaped concrete weir
B. Length	130 feet
C. Crest Elevation	110.6 feet
D. Upstream Channel	Varies ² (Charles River)
E. Downstream Channel	±102.7 feet (Charles River)

1.3.6 Outlets

A. Type	Two 4 feet by 6 feet steel slide gates at right side of spillway.
B. Pipe Invert	±104 feet (no intake our outlet pipe associated with gates)
C. Pipe Size	4 feet by 6 feet maximum gate opening
D. Valve Type	Slide gates

1.3.7 Design and Construction Records and History

Design and construction records for the dam's original construction (presumably timber crib) were not available. Portions of the FST design drawings and some construction photographs of the major reconstruction dated 1934 were made available to GZA during the conduct of our Phase II analyses and were included in our Phase II report. Please refer

¹ Note FST Drawings depict top of dam at approximately elevation 106 feet. Norwood Engineering survey in 2009 uses NGVD-1929, which apparently is different from that used in 1934.

² Depth to mudline on front-side of spillway observed to range generally from 2 to 7 feet below top during diving survey conducted as part of 2009 Phase II scope .



to **Appendix F** for select historic documentation. It is unknown whether the 1934 reconstruction was at the same location as the original structure. No remnants of the original structure were observed during the 2009 diving survey.

1.3.8 Operating Records

There are no operating records for the dam.

1.4 SUMMARY DATA TABLE

See **Table 1.1** on the following page.

1.1 Summary Data Table

Required Phase I Report Data	Data Provided by the Inspecting Engineer
National ID #	MA00341
Dam Name	Charles River Dam at South Natick
Dam Name (Alternate)	South Natick Dam
River Name	Charles River
Impoundment Name	Charles River
Hazard Class	High
Size Class	Intermediate
Dam Type	Earth embankment with concrete gravity run-of-river spillway
Dam Purpose	Recreation
Structural Height of Dam (feet)	15
Hydraulic Height of Dam (feet)	12
Drainage Area (sq. mi.)	165±
Reservoir Surface Area (acres)	Dam is run-of-river structure on the Charles River.
Normal Impoundment Volume (acre-feet)	220
Max Impoundment Volume ((top of dam) acre-feet)	~500
SDF Impoundment Volume* (acre-feet)	N/A structure is on the Charles River.
Spillway Type	Concrete gravity ogee weir (slightly curved in upstream direction.
Spillway Length (feet)	130
Freeboard at Normal Pool (feet)	5±
Principal Spillway Capacity* (cfs)	5870
Auxiliary Spillway Capacity* (cfs)	N/A
Low-Level Outlet Capacity* (cfs)	UNKNOWN
Spillway Design Flood* (flow rate - cfs)	500 YR. / 5,000 (2009 IDA)
Winter Drawdown (feet below normal pool)	No winter draw down.
Drawdown Impoundment Vol. (acre-feet)	N/A
Latitude	42.271555
Longitude	-71.315818
City/Town	Natick
County Name	Middlesex
Public Road on Crest	No
Public Bridge over Spillway	No
EAP Date (if applicable)	Updated by GZA in 2012.
Owner Name	Town of Natick
Owner Address	75 West Street
Owner Town	Natick, MA 01760
Owner Phone	508-647-6551
Owner Emergency Phone	508-647-6550
Owner Type	Municipality or Political subdivision
Caretaker Name	Department of Public Works
Caretaker Address	75 West Street
Caretaker Town	Natick, MA 01760
Caretaker Phone	508-647-6551
Caretaker Emergency Phone	508-647-6550
Date of Field Inspection	10/13/2017
Consultant Firm Name	GZA GeoEnvironmental, Inc.
Inspecting Engineer	Charles B. Nourse, P.E.
Engineer Phone Number	781-278-5764

*In the event a hydraulic and hydrologic analysis has not been completed for the dam, indicate "No H&H" in this table, recommendation section shall include specific recommendation to hire a qualified dam engineering consultant to conduct analysis to determine spillway adequacy in conformance with 302 CMR 10.00.



2.0 INSPECTION

2.1 VISUAL INSPECTION

Charles River Dam at South Natick was inspected by GZA Engineers Mr. Charles B. Nourse, P.E., and Ms. Maha F. Jarrar on October 13, 2017. At the time of the inspection, the weather was sunny with temperatures in the upper 60s. Photographs to document the current conditions of the Dam were taken during the inspection and are included in **Appendix B**. The reservoir elevation at the time of the visit was about 110.7 feet (or about 1 inch above the spillway crest). Underwater areas were not inspected as part of our current scope of work. Note however, that a limited diving survey of the upstream gates, spillway crest and training walls was conducted as part of our 2009 Phase II study. A copy of the completed inspection checklist is included in **Appendix C**.

2.1.1 General Findings

In general, Charles River Dam at South Natick was found to be in **FAIR** condition. There are mature trees scattered over the crest and downstream embankment. Given the width of the dam, it does not appear that there would be an imminent stability issue if one the trees were to overtop. However, continued lack of maintenance may result in a downgrade to Poor in future inspections. Other deficiencies (similar to those observed during the 2015 Phase I inspection and 2009 Phase II study) were noted during the visual inspection, which are identified in more detail in the sections below.

2.1.2 Dam

Embankment Crest

The crest of the earth embankment portion of the dam (mostly on the right embankment) is vegetated with a number of mature trees, high shrubs and grass. The embankment crest varies in width, though its narrowest point is relatively wide at about 23 ft. The numerous tree roots make for an irregular surface at the crest of the embankment. Portions of the embankment between the spillway and the right abutment appeared to potentially be natural ground. The entire length of the upstream slope of the embankment was heavily vegetated which prevented close inspection of the slope conditions.

Downstream Slope

The downstream slope of the right earth embankment is covered with mature trees, high dense shrubbery and some grass. Some standing water and minor leakage (less than 1 gpm) was observed at the blocked masonry sluiceway near the right abutment of the dam. A muddy area with some standing water was present immediately beyond the toe forming a backwater pool, which runs parallel to the downstream embankment between the embankment toe and the Pleasant Street roadway embankment to the confluence with the main Charles River channel. This backwater condition is known to fluctuate based on river flow levels. It has been observed that this low area beyond the toe seasonally fills with backwater from the Charles River. Our review of the 1934 FST design drawings indicates that this low area immediately down gradient from the toe of the right embankment was to be filled to elevation 98 (which corresponds to approximately elevation 108 when taking into account the approximately 10-foot difference between datum used in 1934 as opposed to the 2009 survey), some four feet above the river's thalweg. The note on the drawing indicated that filling was to be done, "if funds permit". However, based on our observations during current and past inspection visits, it appears as though filling of this area was not undertaken. No other areas of wetness, standing



water, or seepage were observed. There were some areas of bare ground and erosion on the downstream slope, likely due to pedestrian traffic and surface water runoff.

Additionally, significant areas of the downstream slope are uneven/undulating. Review of FST's 1934 drawings indicate the original design intent was to construct a more even/uniform embankment at a 2 ½ H : 1V slope. It is unknown if the embankment was constructed as currently configured (during the circa 1934 reconstruction) or whether time, vegetative growth, and/or high backwater contributes to periodic erosion of this area.

Downstream Masonry Wall

The vertical stone masonry wall which comprises a portion of the downstream face of the embankment near the spillway is generally in fair condition. Additionally, a few small, approximately 2-inch diameter, rodent holes were observed just downstream of the wall base, similar to the 2015 inspection. It also appears that rodents are active within the wall as evidenced by holes and loss of soil along its base.

Upstream Slope

The upstream slope is wooded and has dense brush undergrowth which obscured close inspection. Remnants of stone riprap, mostly sediment-filled with vegetation were observed near the waterline, the slope seems to be absent of engineered riprap. Some erosion at the waterline was present likely due to visitors who fish from the upstream slope.

Upstream Masonry Wall

The wall alignment of the mortared stone masonry wall at the upstream left of the spillway appeared to be uneven due to the growth of a moderately sized tree through the stone. This and other smaller trees growing within the wall were removed circa 2011. Vegetative growth has re-established along the wall, and up to 4 to 5-inch separation from the curb of about 40 feet of the low masonry training wall (measured from transition from high masonry wall) was observed. Some cracking and loose stone/mortar were observed near where the stumps remain. The low concrete training walls upstream of the left spillway training wall were in poor condition with cracked, spalled, and significantly misaligned sections of deteriorated cast-in-place concrete.

Depressions and unevenness were observed at the paved walkway behind the wall section at the spillway. Review of the FST Drawings indicates the stone masonry along this portion of the wall apparently serves is facing behind which is a reinforced concrete wall. Nevertheless this condition may be indicative of possible underlying erosion issues or loss of ground behind or through the wall in this area.

Miscellaneous

The iron railing on top on the right upstream training wall did not cover the full extent of the wall and should be extended to provide additional safety from the River/spillway portion below. Additionally, though not a dam safety concern, portions of the iron railing on the left abutment/spillway appeared bent/damaged and should be replaced.

2.1.3 Appurtenant Structures

Primary Spillway

The concrete spillway was partially obscured by overflow at the time of inspection. The apron was observed to be in fair to good condition with no significant deterioration, cracking or voids. Visual inspection of the contact between the



apron and the streambed immediately downstream indicated potential areas of undermining, scour or streambed erosion. The concrete fishway at the right side of the spillway was flowing clear at the time of the inspection. The concrete was in poor condition with localized holes along portions of the left side. Baffles were observed to be in place, but flow over them precluded close inspection.

A more detailed inspection along the upstream side of the spillway was done during the Phase II work at the dam by GZA in 2009. This consisted of a dive team inspecting the condition of the upstream side of the spillway starting at the west end of the outlet structure. The results of the underwater inspection revealed a horizontal crack located 2 feet above the mudline. The crack was approximately 0.25-inches wide and radiates 14 inches to the west from a construction joint approximately 40 feet west of the bull-nose. The underwater inspection also revealed significant amounts of sediment, tree waste and miscellaneous debris submerged beneath the waterline on the upstream side of the weir.

The spillway has upstream and downstream stone masonry training walls. The stone masonry was generally in fair condition. Some missing stones were observed at localized portions along the right training wall, particularly near the water line. Loss of stone along the contact of the downstream ogee portion with the left side of the spillway appears to have slightly increased since the 2015 inspection. In 2010, the Town enacted repairs of a large hole in the left downstream low stone wall at its transition downstream of the high wall. This hole was originally reported in the 2008 Phase I report. The repairs appear to be performing well. The remainder of the left side is generally even with localized loss of ground and missing stones. The alignment of the downstream masonry wall is generally good.

The low stone wall on the right side was also missing stones in localized areas and generally has a slight lean toward the river with loss of ground/ground subsidence observed immediately behind the wall. A crack was observed during the 2013 and 2015 inspections in the top of the low portion of the right training wall approximately 10 feet downstream of the high to low transition point. This crack was also observed during this inspection. A smaller top crack was observed further downstream where the right wall begins its turn parallel with the dam's axis.

Outlet Structure

The concrete associated with the outlet structure at the right spillway abutment was generally in fair to poor condition. Concrete deterioration, chipping, spalling, efflorescence, pitting, and evidence of past minor leakage/wetness were observed at the downstream left side of the gate outlets. There was evidence of past minor leakage in the concrete wall at the downstream left side of the outlet in the form of wetness/staining. Erosion/minor void(s) were observed in the concrete along left side of outside concrete wall of outlet structure at the waterline.

Gate guides on the upstream side show rusting and are in poor condition. Gate operators have been painted and are in good condition considering their age (circa 1934). No wheel/crank arm for the operators was present at the time of inspection. The Town has a functional homemade crank wheel at DPW headquarters.

The brass stems on the gates appeared to be in fair to good condition at the time of inspection. The right gate was raised slightly in 2008 via the portable crank arm on the right operator to confirm the operability of the stem. A more intense underwater diving inspection undertaken as part of the 2009 Phase II inspection indicated that the slide grooves, the gate hardware including the brass compression wedges were significantly deteriorated. The gates are deemed inoperable and due to their 80-plus-year age are in need of replacement rather than repair.



Instrumentation

As part of the 2009 Phase II study an exploration program consisting of four (4) test borings were drilled to aid in the analyses. Observation wells and open standpipe piezometers were placed in three of the borings. Refer to **Figure 5** for approximately locations. Water level readings were taken at each well/piezometer during this inspection and are reported in the Inspection Checklist. It should be noted that the piezometric water surface elevation in the piezometer in GZ-2 was approximately 2.4 feet higher than the phreatic surface water elevation recorded in the observation well in this same borehole. This observance is indicative that little upward flow is present within the embankment at this location and supports our 2009 seepage/stability analysis which judged the embankment as having acceptable factor of safety values.

2.1.4 Downstream Area

The downstream area consists of the Charles River and the Pleasant Street Bridge. A park area extends downstream from the dam to the bridge at the left overbank. Based on the 1934 FST drawings, the former sluiceway channel once connected the abandoned low level outlet to the main stem of the Charles River near the right overbank. This channel appears to occasionally inundate due to backwater effects during high flow. This backwater condition may contribute to the undulation/unevenness currently observed on the downstream earthen embankment.

2.1.5 Reservoir Area

The impoundment is the Charles River. The shoreline of the impoundment area consists of woodlands and residential structures. The banks slopes are moderate, but appear stable.

2.2 CARETAKER INTERVIEW

Maintenance of the dam is the responsibility of the Town of Natick, Department of Public Works. Mr. William McDowell, P.E., Town Engineer and dam caretaker, was present at the start of inspection and was in correspondence with GZA before and after the inspection. Mr. McDowell remains available should there be a need to address immediate concerns with the dam. The maintenance of the dam typically includes mowing of the left abutment area and periodic cleanup of debris from the spillway and earthen embankment. The gates have reportedly not been exercised for several decades apart from the efforts in 2008. The fishway is not operated and may not be functional.

2.3 OPERATION AND MAINTENANCE PROCEDURES

2.3.1 Operational Procedures

There is no formal operational procedure at the dam. Development of an Operation and Maintenance Plan (OMP) is recommended.

2.3.2 Maintenance of Dam and Operating Facilities

There is no formal operations and maintenance plan for the dam.

2.4 EMERGENCY WARNING SYSTEM

GZA completed an Emergency Action Plan (EAP) for the dam in December of 2006 for the Town of Natick. The plan was last updated in 2012 by GZA and is on file with DCR-ODS. It is recommended that the EAP and contact



names/numbers, etc., is updated annually per DRC dam safety regulations. The Town has handled this annual update in the past.

2.5 HYDROLOGIC/HYDRAULIC DATA

Based on the **Intermediate** size and **High** (Class I) hazard classification for the dam, the spillway design flood (SDF) for the dam is the $\frac{1}{2}$ PMF.

Hydrologic/hydraulic analysis of the dam was conducted in 1987 as part of a previous dam inspection report and is contained in DCR's files. This previous analysis developed the $\frac{1}{2}$ PMF using nomographs, which were produced by the U.S. Army Corps of Engineers in the late 1970s and estimated the $\frac{1}{2}$ PMF peak inflows as 6,600 cfs. The USACE developed their maximum Probable Flood Peak Flow Rates curves from data available for sites on reservoirs in New England where they had such data for reservoirs or had developed a Standard Project Flood (SPF). The SDF was doubled by the USACE to provide a value of Maximum Probable Flows. The peak flow at the Charles River Gage was estimated by USACE at 65 cfs per square mile. Re-apportioned at the dam, the unit discharge is about 80 cfs per square mile at the dam. This results in a peak full Probable Maximum Flood of 13,200 cfs and one-half the Probable Maximum Flood of 6,600 cfs at the Charles River Dam at South Natick.

As part of the 2009 Phase II assessment, GZA conducted an Inflow Design Flood (IDF)³ analysis to evaluate if a less severe flood than the $\frac{1}{2}$ PMF may be more appropriate as the SDF. The IDF is the flood flow above which the incremental increase in water surface elevations downstream of the dam (due to dam failure) is not considered to present an unacceptable threat to downstream life and property. In the case of the Charles River Dam at South Natick, a flood less than the $\frac{1}{2}$ PMF may be adopted as the SDF if the consequences of dam failure at flood flows larger than the selected SDF are acceptable (i.e. no increased damage to downstream areas is created by dam failure) in accordance with 302 CMR 10.14(6)(c). In general, the consequences of failure are considered acceptable when the incremental effects (depths) of failure on downstream structures are approximately two feet or less⁴. The SDF is therefore selected as the highest intensity flood causing incremental impacts of greater than two feet.

The IDF analysis was conducted by GZA for scenarios with and without breaching the dam, for both the $\frac{1}{2}$ PMF and 500-year flood conditions. The hydraulic computer model HEC-RAS⁵ was used to perform one-dimensional hydraulic calculations for unsteady-state flow water surface and to predict the hypothetical dam break wave formation at Charles River Dam at South Natick and the wave's downstream progression along the Charles River.

Under the $\frac{1}{2}$ PMF, the peak discharge at Charles River Dam, without dam failure, is about 6,600 cfs. A potential dam break at Charles River Dam, during the $\frac{1}{2}$ PMF, results in a peak flow through the breach opening of about 7,200 cfs. The analyses indicated that the difference in downstream peak depths, with and without Charles River Dam failure, is less than 0.5 feet throughout the downstream reach. Submergence issues affect the flow release for the dam failure.

³ Federal Energy Regulatory Commission-Office of Hydropower Licensing, "Engineering Guidelines for the Evaluation of Hydropower Projects," revised October 1993.

⁴ Federal Emergency Management Agency, Mitigation Directorate, National Dam Safety Program (FEMA 94), "Federal Guidelines for Dam Safety: Selection and Accommodating Inflow Design Floods for Dams", prepared by the Interagency Committee on Dam Safety, October 1998.

⁵ U.S. Army Corps of Engineering, *River Analysis System (HEC-RAS) Version 4.0.0*. (March, 2008).



Under the 500-year flood, Peak flow downstream of the dam without dam failure, is about 5,000 cfs. With dam failure, the peak discharge through the Charles River Dam breach opening is approximately 6,630 cfs. The analyses indicated that the difference in downstream peak depths with and without Charles River Dam failure is less than 1 foot throughout the downstream reach. Submergence issues affect the flow release for the dam failure.

GZA's IDF analysis results indicate that, the populated areas downstream of Charles River Dam may experience a difference in incremental peak flood depths of less than 0.5 feet with dam failure. This is an indication that the 500-year flood may be at the threshold of what constitutes a significant difference in downstream peak flood elevations. GZA, on behalf of the Town petitioned DCR-ODS to adopt the 500-year as the SDF at Charles River Dam. DCR-ODS concurred with GZA's recommendation and issued the formal petition granting the reduction to the 500-year event on January 4, 2010.

Topographic survey conducted during the Phase II assessment, shows that the spillway has a maximum available freeboard of about 5.4 ft. (116 ft. (top of dam) – 110.6 ft. (spillway crest)) and a length of approximately 130 feet. Using a typical weir coefficient of 3.6 for an ogee-shape weir, combined with the aforementioned spillway dimensions, GZA estimates the capacity of the spillway is about 5,870 cfs, or about 117-percent of the (IDA approved 500-year) SDF value of 5,000 cfs.

The following are based on the 2009 Phase II analysis.

A. Spillway Design Flood (SDF) Return Period:	500-year
B. Precipitation (inches) and methodology:	Unknown
C. SDF Inflow (cfs):	5,000
D. SDF Outflow (cfs):	5,000
E. Principal Spillway Capacity (cfs):	5,870
F. Auxiliary Spillway Capacity (cfs):	N/A
G. Low-level Outlet Capacity (cfs):	Unknown
H. Percentage of the SDF that can be safely routed through the reservoir without overtopping the dam:	>100%
I. Minimum Freeboard (ft.) (if applicable)	0.7

While the H&H analyses indicates the spillway has adequate capacity to pass the revised SDF (500-year-flood), the calculated freeboard under this condition is only about 0.7 feet which is less than the recommended 2-foot minimum. A potential exists for overtopping of the embankment via wave action under the SDF. Thus, it is recommended that measures dealing with overtopping protection be taken to address this deficiency.

2.6 STRUCTURAL AND SEEPAGE STABILITY

2.6.1 Embankment Structural Stability

As part of the Phase II analysis, GZA performed a dimensional stability analysis at the maximum embankment section of the Charles River Dam at South Natick where the risk for instability was assumed to be the greatest. The analyses were performed in general accordance with ODS regulations (302 CMR 10.14(9)) as well as other industry standards



from the United States Bureau of Reclamation, United States Army Corp of Engineers, and Federal Energy Regulatory Commission.

The analyses indicated acceptable factors of safety under all loading cases. Based on the overall results of the stability assessment, the embankment was judged to be structurally stable and stability-related corrective actions are not required. Back-up calculations are contained in the Phase II report.

2.6.2 Structural Stability of Non-Embankment Structures

There are no non-embankment structural stability analyses available for the dam in DCR's files. The 2009 Phase II scope did not include a structural stability analysis of non-embankment structures. GZA did not observe any signs of structural instability of the non-embankment structures during the visual inspection.

2.6.3 Seepage Stability

Seepage Analyses were conducted as part of the 2009 Phase II assessment. The seepage analyses indicated that under maximum pool conditions with the upstream water surface level at elevation 115.1 feet and the downstream water surface at 112.7, the maximum exit gradient of water in the embankment at the toe of the dam is about 0.15 (foot/foot). The calibrated normal pool model indicated that the maximum exit gradient is approximately 0.11. Taking the critical gradient (which is the gradient slope at which soil transport and thus potential piping failure is assumed to begin) as 1.0, as is typically done for these analyses, the computed exit gradient is lower than the critical gradient, indicating that soil transport is likely not a concern at the dam, in GZA opinion.

3.0 ASSESSMENTS AND RECOMMENDATIONS

3.1 ASSESSMENTS

In general, the overall condition of Charles River Dam at South Natick is **FAIR**. The dam was found to have the following deficiencies:

1. Mature trees and shrubs throughout earth embankment on right side of spillway;
2. Minor erosion at top of earth embankment and downstream embankment due to pedestrian traffic;
3. Minor leakage through blocked, abandoned outlet at downstream toe of earth embankment near the right abutment;
4. Minor scarping and some erosion at waterline at upstream slope of earth embankment;
5. Deteriorated cast-in-place concrete with cracked, spalled and misaligned sections associated with the low training wall upstream of the left spillway abutment;
6. Some missing stones and loose/missing mortar at stone masonry spillway training walls on both left and right sides of the spillway discharge channel (Charles River);
7. New tree/vegetation growth re-establishing within joints of left and right stone masonry spillway training wall;
8. Slight lean toward the river of the low retaining wall on right side of the spillway discharge area and loss of ground/ground subsidence behind wall;
9. Deteriorated cast-in-place concrete with cracked, chipped, spalled sections associated with the low-level outlet slide gate structure on the right spillway abutment;



10. Erosion/minor void in concrete along left side of outside concrete wall of outlet structure at waterline; and
11. Inoperable slide gates at the outlet works.

A comparison to the previously reported condition of the dam is shown below:

<i>Previously Identified Deficiency(2015)</i>	<i>Resolution or Current Condition</i>
Mature trees and shrubs throughout earth embankment on right side of spillway.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Minor erosion at top of earth embankment and downstream embankment due to pedestrian traffic.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Minor leakage through blocked, abandoned outlet at downstream toe of earth embankment near the right abutment.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Minor scarping at waterline at upstream slope of earth embankment.	Similar condition where observed. Dense vegetative cover obscured view of much of the upstream slope.
Deteriorated cast-in-place concrete with cracked, spalled and misaligned sections associated with the low training wall upstream of left spillway abutment.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Some missing stones and loose/missing mortar at stone masonry spillway training walls on both left and right sides of the spillway discharge channel (Charles River).	Slight deterioration from 2015 condition. GZA also noted upstream left training wall separated from the curb approximately 4 to 5 inches.
Although vegetation/trees growing within joints of left stone masonry spillway training wall were recently cut, the stumps/rootballs remain. New tree/vegetation growth re-establishing.	Vegetation continuing to reestablish with new tree growth.
Slight lean toward the river of the low retaining wall on right side of the spillway discharge area and loss of ground/ground subsidence behind wall.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Evidence of minor leakage in the form of staining in concrete at outlet structure on right side of spillway.	This deficiency was not observed during the 2015 or 2017 inspections.
Deteriorated cast-in-place concrete with cracked, chipped, spalled sections associated with the low-level outlet slide gate structure on the right spillway abutment.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Erosion/minor void in concrete along left side of outside concrete wall of outlet structure at waterline.	This condition remains and is generally similar to conditions observed in the 2015 inspection.
Inoperable slide gates at outlet works.	Slide gates remain inoperable and are recommended for replacement.



3.2 STUDIES AND ANALYSES

GZA recommends that the following investigations be performed by a qualified, registered professional engineer experienced in dam safety:

1. Prepare written operations and maintenance plan;
2. Continue to review and update the Emergency Action Plan (EAP) annually to update contact names/numbers, etc., as appropriate. The Town has handled the annual updates in the past;
3. Continue monitoring the condition of stone masonry and concrete spillway training walls;
4. Continue monitoring the condition of concrete associated with slide gate outlet structure;
5. Continue monitoring the leakage at the blocked former outlet for increases in flow rate and clarity of flow; and
6. Conduct a detailed inspection of the downstream face of spillway. Note, it is envisioned that this could be prudently accomplished after the slide gates have been replaced at which time they could be opened slightly to lower the water level enough such that the downstream side of the spillway is clearly exposed. It is noted that flow over the spillway during this (2017) inspection was low which allowed for an improved level of inspection of this area.

3.3 RECURRENT MAINTENANCE RECOMMENDATIONS

GZA recommends the following recurrent maintenance level activities that can be undertaken by the dam owner/caretaker and do not require engineering design:

1. Maintain a program of brush removal and grass trimming at the earthen embankment.

Additional detail regarding annual maintenance activities should be listed in an officially prepared Operations and Maintenance (O&M) Manual.

3.4 MINOR REPAIR RECOMMENDATIONS

GZA recommends the following minor repairs:

1. Remove vegetation which has re-established within joints of left and right stone masonry spillway training wall including, to the extent practicable, removal of associated stumps and rootballs.

3.5 REMEDIAL MODIFICATIONS RECOMMENDATIONS

The following more comprehensive remedial measures were formulated based primarily on the results of GZA's 2009 Phase II evaluation and include actions to bring the structure into compliance with Massachusetts Dam Safety Regulations and current engineering practice.

1. Clear trees and woody vegetation from the embankments, crest and downstream toe area. Additionally remove all roots/root balls associated with trees and vegetation and backfill resulting voids with compacted sand/gravel;
2. Re-surface the upstream embankment with stone rip-rap protection;



3. Re-grade the downstream embankment to a uniform 3H:1V slope. Place proprietary turf reinforcement matting over the crest and downstream slope to address potential for crest overtopping via wave action and erosion of the downstream slope via high backwater conditions;
4. Execute a complete replacement of both gates coupled with appropriate re-configuration/restoration of the concrete superstructure surrounding the gate openings; and
5. Repair/re-build the upstream and downstream training wall portions of the spillway discharge area which exhibit deteriorated concrete, missing stones/mortar and related deficiencies.

3.6 ALTERNATIVES

No Action: The “No Action” alternative is not considered a viable option due to the observed safety deficiencies at the dam in relation to its “High” hazard classification. Failure to address the identified deficiencies would be a violation of Massachusetts Law (G.L. c. 253, § 44-49 as amended by Chapter 330 of the Acts of 2002) and Massachusetts regulations (302 CMR 10.00) which require an Owner to properly maintain their dam such that it meets minimum dam safety standards. Failure to correct the dam safety deficiencies identified at the Charles River Dam could endanger downstream public safety and property.

Dam Breach: Breaching or removing the dam in a controlled and engineered manner would eliminate the failure-induced flooding threat to downstream public safety posed by an uncontrolled release of the impoundment. Removal would serve to restore the natural riverine condition along this section of the Charles. The historical significance, if any, of the dam structure should be researched before moving forward with this alternative. Chemical testing of the accumulated sediment just upstream of the spillway would be required to evaluate the disposal requirements and associated costs. Sediment management during execution of the breaching process would also require study to determine potential impacts. The presence of sediment contamination could greatly increase the cost for removal.

For these and other reasons, it should be noted that engineering and permitting costs associated with breaching the dam could approach or even exceed estimated costs associated with implementation of the full suite of recommended repairs. While removal would mitigate ownership risks for the Town, there are several other dams, both upstream and downstream along the river, which are close to this dam. Removal of this dam therefore would have only minimal effect with regard to improving fish passage.

3.7 OPINION OF PROBABLE ESTIMATED STUDY AND CONSTRUCTION COSTS

Study Item	Conceptual Cost
Prepare a formal Operations & Maintenance Plan	\$6,000
Continue review of the Emergency Action Plan (EAP) and update contact names/numbers, etc.,	See Note 1
Total	\$6,000



Minor Repairs and Remedial Measures	Conceptual Cost
Clear trees and woody vegetation from the embankments, crest and downstream toe area. Additionally remove all roots/root balls associated with trees and vegetation and backfill resulting voids with compacted sand/gravel.	\$65,000 - \$90,000
Re-surface the upstream embankment with stone rip-rap protection.	\$190,000 - \$245,000
Re-grade the downstream embankment to a uniform 3H:1V slope. Place proprietary turf reinforcement matting over the crest and downstream slope to address potential for crest overtopping via wave action and erosion of the downstream slope via high backwater conditions.	\$150,000 - \$195,000
Execute a full gate replacement coupled with appropriate re-configuration/restoration of the concrete superstructure surrounding the gate openings is recommended.	\$550,000 - \$670,000
Repair/re-build the upstream and downstream training wall areas which deteriorated concrete, missing stones/mortar and related deficiencies.	\$315,000 - \$370,000
Total	~\$1,270,000 - \$1,570,000

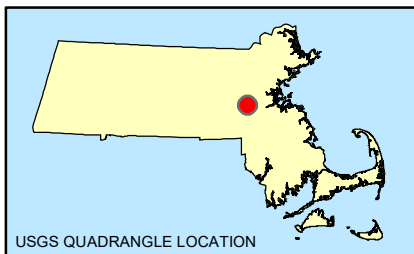
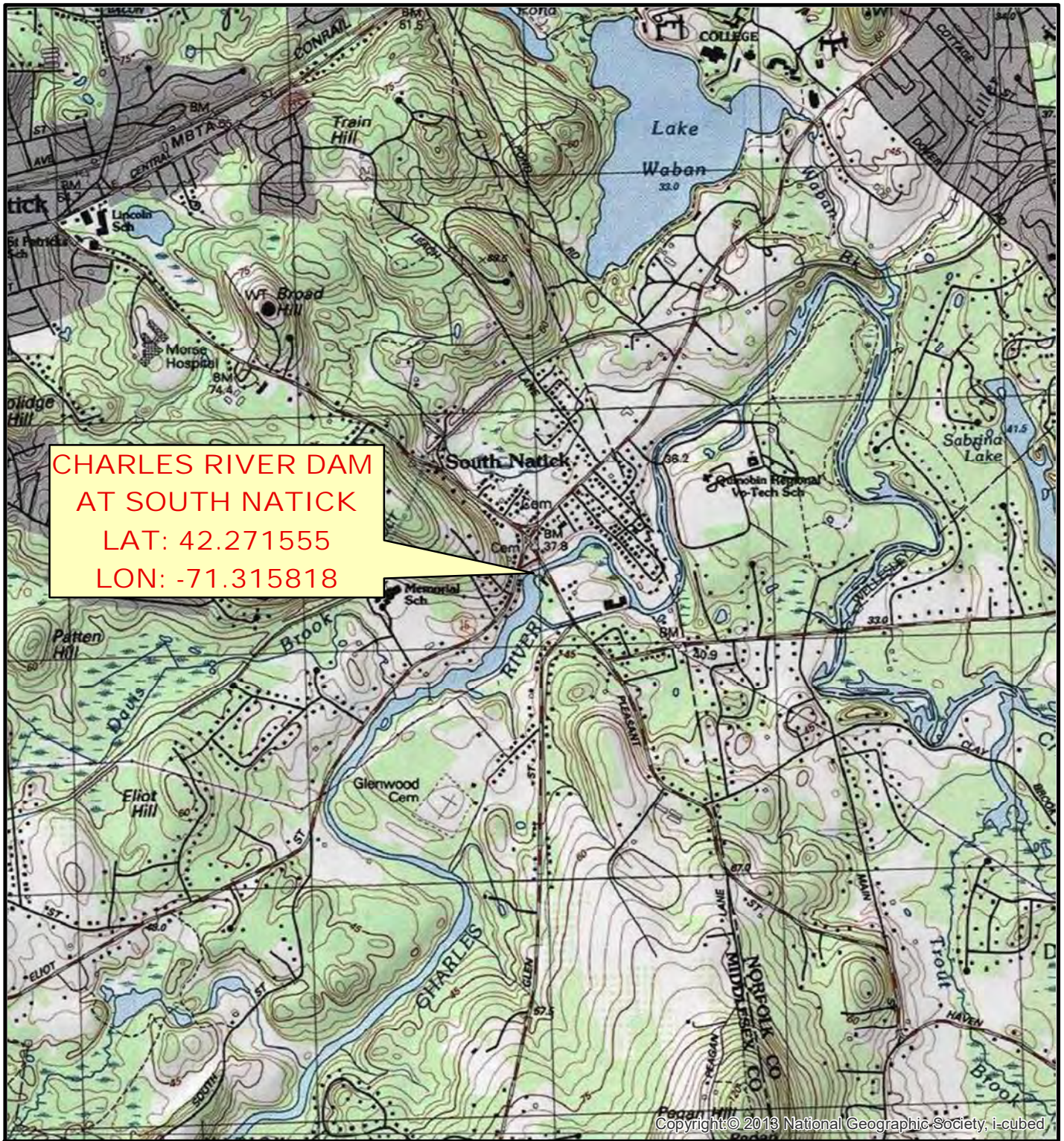
Notes:

1. EAP last thoroughly reviewed by GZA in 2012, therefore no budget carried for this item.
2. Cost estimate information presented above is for comparative, or general planning purposes and includes a 20 percent allowance for contingencies. The estimate may involve approximate quantity evaluations and is not sufficiently accurate to develop construction bids, or to predict the actual cost of work. Further, since GZA has no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated above. A more detailed cost estimate would typically be developed by the design engineer during the design as the specific scope of construction services is clarified.
3. Estimate above does not include final engineering design, permitting or resident engineering costs which would be on the order of additional 20 to 30 percent.

The Town continues the process of refining costs estimated to effect implementation of the preferred repair alternatives as outlined in the 2009 Phase II study. Funds to repair deficiencies are a part of the Department of Works annual Capital Planning/Budget request process. Additionally the Town has in the past applied to the Dam and Seawall Repair or Removal Program which offers financial resources to qualified applicants for projects that share the mission to enhance, preserve, and protect the natural resources and the scenic, historic and aesthetic qualities of the Commonwealth of Massachusetts. Unfortunately they have been unsuccessful in securing any funding through this program, but plan on re-applying during future open application periods.



FIGURES



SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES
SCANNED BY THE MASSACHUSETTS EXECUTIVE OFFICE OF
ENVIRONMENTAL AFFAIRS, MASSGIS. DISTRIBUTED JUNE, 2001.

Data Supplied by :



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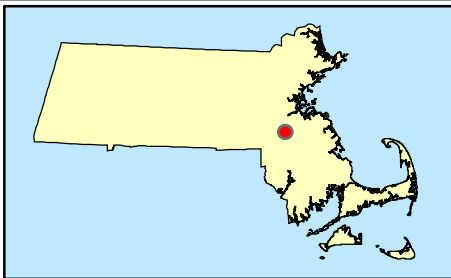
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DESIGNED BY: CBN
REVIEWED BY: PHB
OPERATOR: CBN
DATE: 10-13-2017

LOCUS MAP

CHARLES RIVER DAM AT SOUTH NATICK
NATICK, MASSACHUSETTS
NID ID# MA00341

JOB NO.
01.0019114.70

FIGURE NO.
1



PROJ. MGR.: CBN
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 OPERATOR: CBN

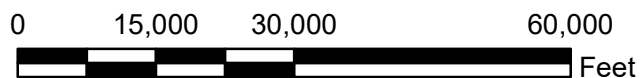
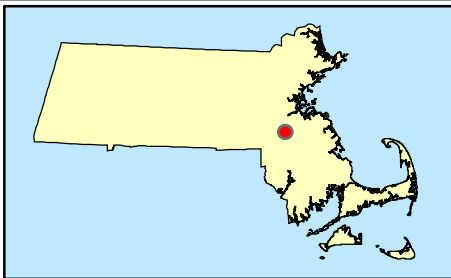
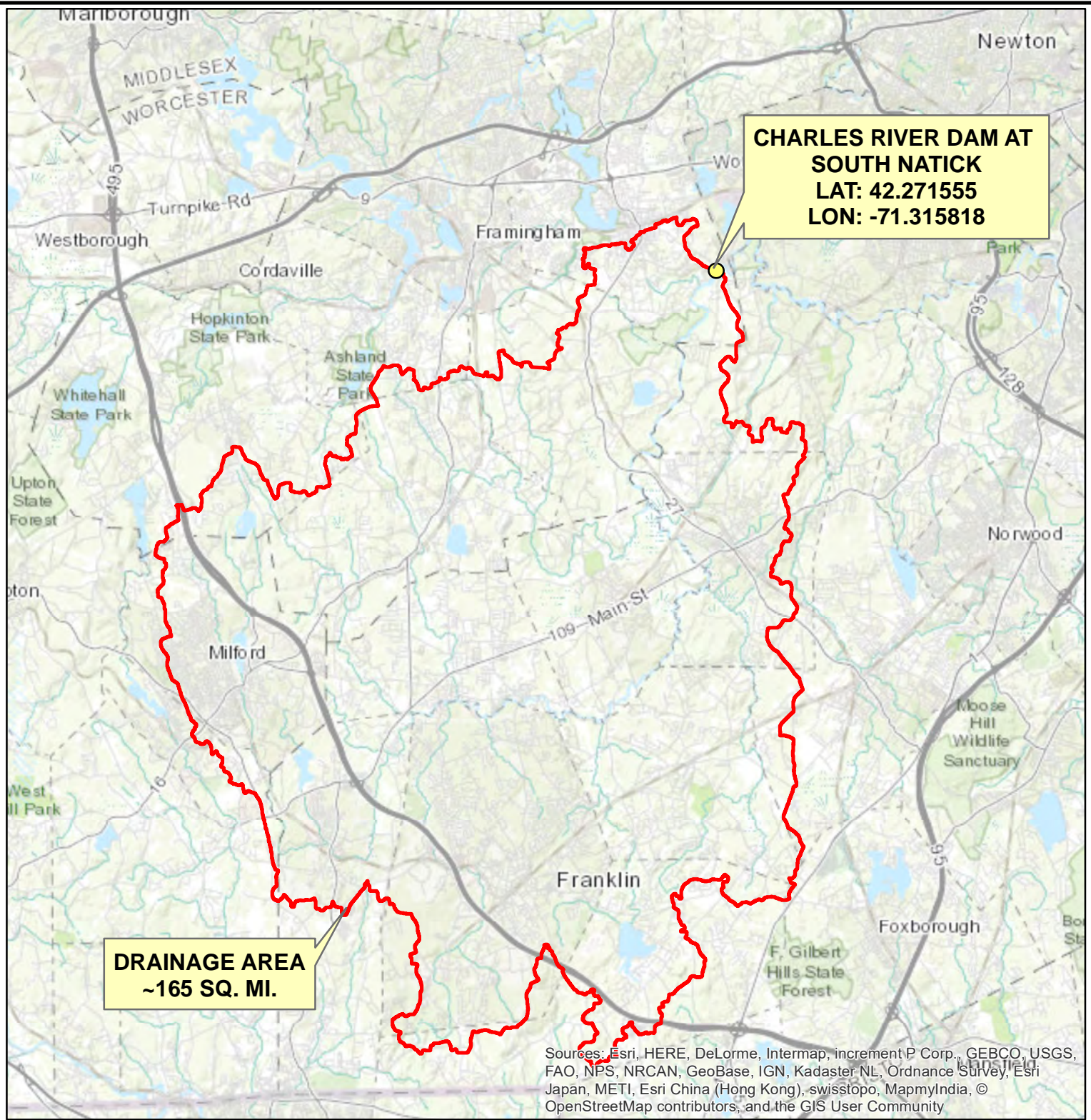
DATE: 10-13-2017

AERIAL PHOTOGRAPH

CHARLES RIVER DAM AT SOUTH NATICK
 NATICK, MASSACHUSETTS
 NID ID# MA00341

JOB NO.
 19114.70

FIGURE NO.
 2



PROJ. MGR.: CBN
 DESIGNED BY: MSA
 REVIEWED BY: CBN
 OPERATOR: CBN

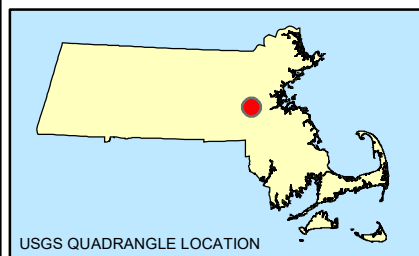
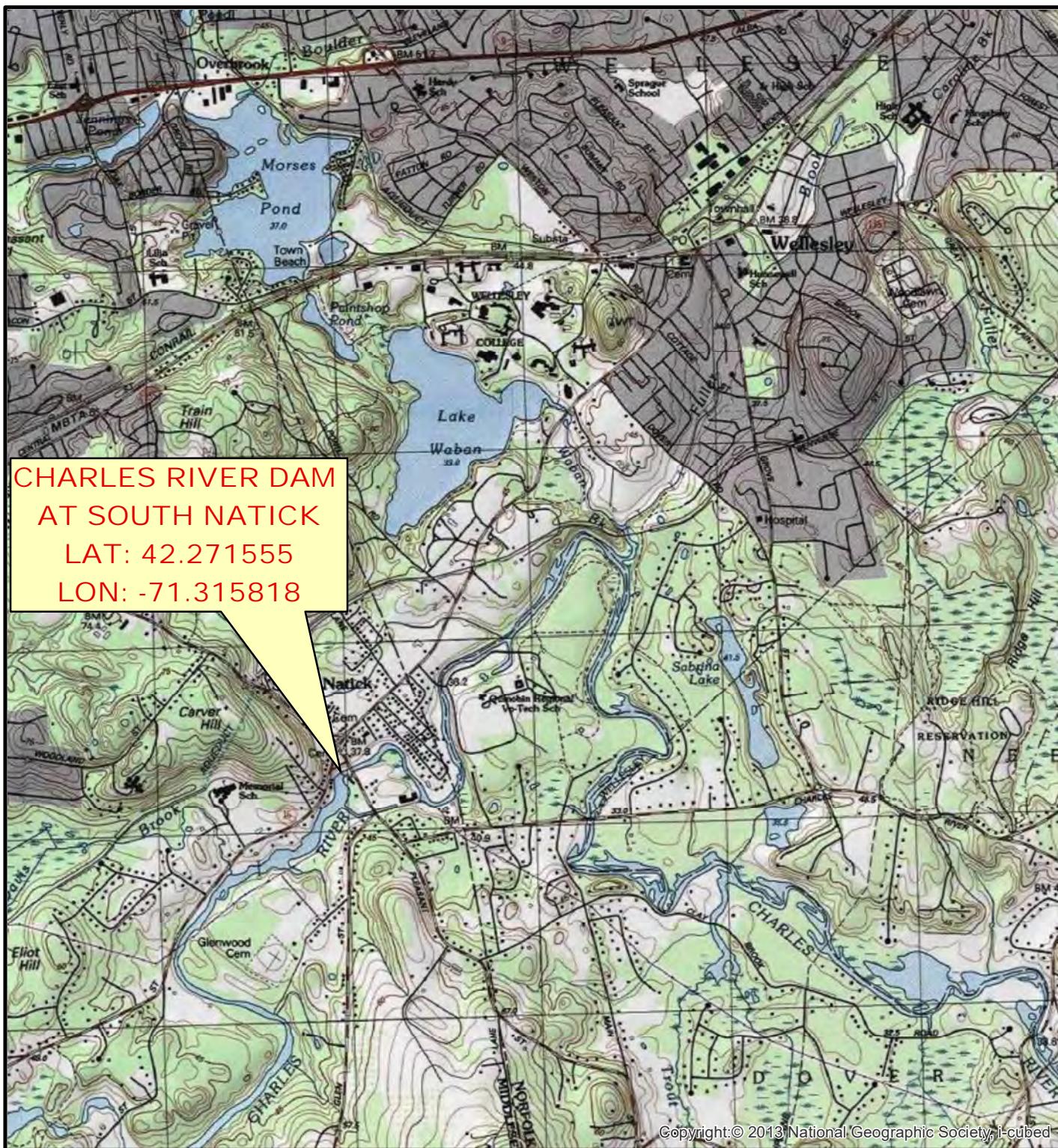
DATE: 10-13-2017

DAM AND DRAINAGE AREA

CHARLES RIVER DAM AT SOUTH NATICK
 NATICK, MASSACHUSETTS
 NID ID# MA00341

JOB NO.
 19114.70

FIGURE NO.
 3



SOURCE : SCANNED USGS TOPOGRAPHIC QUADRANGLES
SCANNED BY THE MASSACHUSETTS EXECUTIVE OFFICE OF
ENVIRONMENTAL AFFAIRS, MASSGIS. DISTRIBUTED JUNE, 2001.

Data Supplied by :



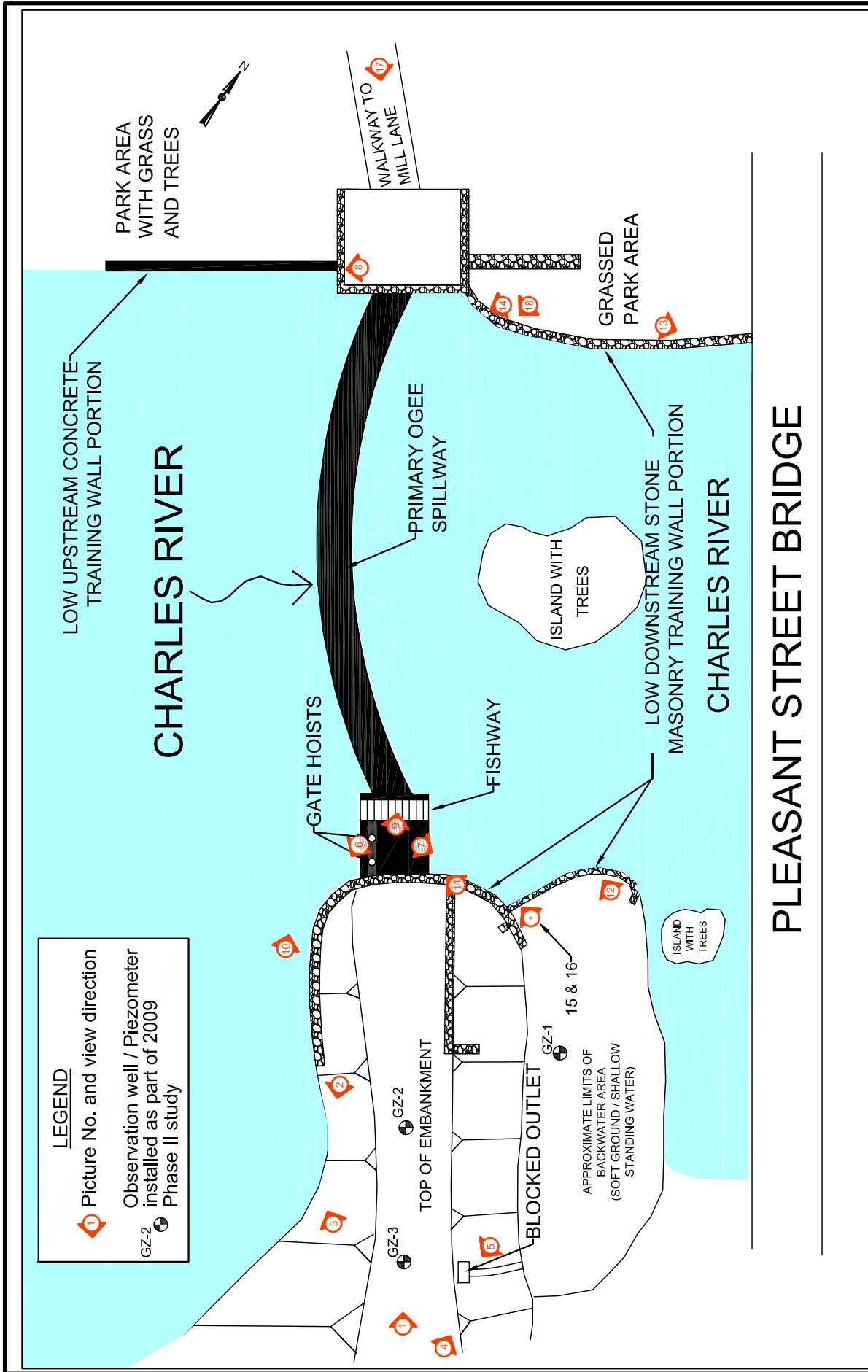
0 1,250 2,500 5,000 7,500 Feet



PROJ. MGR.: CBN
DESIGNED BY: CBN
REVIEWED BY: PHB
OPERATOR: CBN
DATE: 10-13-2017

DAM AND DOWNSTREAM AREA
CHARLES RIVER DAM AT SOUTH NATICK
NATICK, MASSACHUSETTS
NID ID# MA00341

JOB NO.
01.0019114.70
FIGURE NO.
4



JOB NO. 19114.70		FIGURE NO. 5	
CHARLES RIVER DAM SOUTH NATICK, MA TOWN OF NATICK		SITE SKETCH WITH PHOTO LOCATIONS	
PROJ MGR: CBN DESIGNED BY: MFJ REVIEWED BY: PHB OPERATOR: MFJ		DATE: 11/10/2017	
NOT TO SCALE		GZA GeoEnvironmental, Inc. 249 VANDERBILT AVE NORWOOD, MA 02062 T: (781) 278-3700 F: (781) 278-5701	



APPENDIX A - LIMITATIONS



DAM ENGINEERING & VISUAL INSPECTION LIMITATIONS

Use of Report

1. GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of the Town of Natick (Client) for the stated purpose(s) and location(s) identified in the Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal, and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).
3. Our services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.

Subsurface Conditions

4. If presented, the generalized soil profile(s) and description, along with the conclusions and recommendations provided in our Report, are based in part on widely-spaced subsurface explorations by GZA and/or others, with a limited number of soil and/or rock samples and groundwater /piezometers data and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then appear evident, it will be necessary to reevaluate the conclusions and recommendations of this report.
5. Water level readings have been made (as described in the Report) in monitoring wells and piezometers, at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this Report. Fluctuations in the groundwater and piezometer levels, however, occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, reservoir and tailwater levels, the presence of subsurface utilities, and/or natural or artificially induced perturbations.

General

6. The observations described in this report were made under the conditions stated therein. The conclusions presented were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of described services or the time and budgetary constraints imposed by the Client.
7. In preparing this report, GZA relied on certain information provided by the Client, state and local officials, and other parties referenced therein available to GZA at the time of the evaluation. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation.



8. Any GZA hydrologic analysis presented herein is for the rainfall volumes and distributions stated herein. For storm conditions other than those analyzed, the response of the site's spillway, impoundment, and drainage network has not been evaluated.
9. Observations were made of the site and of structures on the site as indicated within the report. Where access to portions of the structure or site, or to structures on the site was unavailable or limited, GZA renders no opinion as to the condition of that portion of the site or structure. In particular, it is noted that water levels in the impoundment and elsewhere and/or flow over the spillway may have limited GZA's ability to make observations of underwater portions of the structure. Excessive vegetation, when present, also inhibits observations.
10. In reviewing this Report, it should be realized that the reported condition of the dam is based on observations of field conditions during the course of this study along with data made available to GZA. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued inspection and care can there be any chance that unsafe conditions be detected.

Compliance with Codes and Regulations

11. We used reasonable care in identifying and interpreting applicable codes and regulations. These codes and regulations are subject to various, and possibly contradictory, interpretations. Compliance with codes and regulations by other parties is beyond our control.
12. This scope of work does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

Cost Estimates

13. Unless otherwise stated, our cost estimates are for comparative, or general planning purposes. These estimates may involve approximate quantity evaluations and may not be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in this Report. Further, since we have no control over the labor and material costs required to plan and execute the anticipated work, our estimates were made using our experience and readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.

Additional Services

14. It is recommended that GZA be retained to provide services during any future: site observations, explorations, evaluations, design, implementation activities, construction and/or implementation of remedial measures recommended in this Report. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.



APPENDIX B - PHOTOGRAPHS



Client Name:

Site Location:

Project No.

Town of Natick, Massachusetts

Charles River Dam at South Natick,
Located Off of Pleasant Street, Natick, Massachusetts

19114.70

Photo No.

Date:

1

10/13/2017

Direction Photo Taken:

Northwest

Description:

Overview along embankment crest from right abutment area. Dense vegetation at upstream and downstream sides of wood chip path obscured close inspection.



Photo No.

2

Date:

10/13/2017

Direction Photo Taken:

South

Description:

Closeup of upstream slope at right earthen embankment portion of dam. Note heavy overgrowth of trees and brush.






Client Name: Town of Natick, Massachusetts		Site Location: Charles River Dam at South Natick, Located Off of Pleasant Street, Natick, Massachusetts	Project No. 19114.70
Photo No. 3	Date: 10/13/2017		
Direction Photo Taken: Northwest			
Description: View of erosion and exposed roots from crest leading to the water's edge on upstream embankment near the right abutment. Several similar erosion areas observed locally along upstream embankment.			

Photo No. 4	Date: 10/13/2017	
Direction Photo Taken: North		
Description: Downstream slope of earthen embankment dam portion from right abutment area. Note heavy vegetative/tree overgrowth.		





Client Name: Town of Natick, Massachusetts		Site Location: Charles River Dam at South Natick, Located Off of Pleasant Street, Natick, Massachusetts	Project No. 19114.70
Photo No. 5	Date: 10/13/2017		
Direction Photo Taken: Southwest			
Description: View of former sluiceway outlet, currently plugged. Minor (less than 1 gallon per minute) clear seepage observed, similar to 2015 inspection. Seepage drains to former discharge channel immediately downstream of the toe of the earthen embankment portion.			

Photo No. 6	Date: 10/13/2017	
Direction Photo Taken: South		
Description: View along upstream side of right spillway training wall from outlet structure.		




Client Name: Town of Natick, Massachusetts		Site Location: Charles River Dam at South Natick, Located Off of Pleasant Street, Natick, Massachusetts	Project No. 19114.70
Photo No. 7	Date: 10/13/2017		
Direction Photo Taken: East			
Description: View along downstream side of right spillway training wall from the outlet structure. Note areas of missing stones and mortar and loss of stone.			

Photo No. 8	Date: 10/13/2017	
Direction Photo Taken: West		
Description: Overview of left upstream spillway training wall from left spillway abutment. Note vegetation beginning to re-establish along wall base and separation of concrete wall and asphalt walkway.		



Client Name:

Site Location:

Project No.

Town of Natick, Massachusetts

Charles River Dam at South Natick,
Located Off of Pleasant Street, Natick, Massachusetts

19114.70

Photo No.

9

Date:

10/13/2017

Direction Photo Taken:

North

Description:

View of ogee spillway and left training wall.
Approximately 1 inch of water flowing over top of spillway during inspection.



Photo No.

10

Date:

10/13/2017

Direction Photo Taken:

North

Description:

View of upstream side of low level outlet gates. Slide gates currently inoperable.





Client Name:

Site Location:

Project No.

Town of Natick, Massachusetts

Charles River Dam at South Natick,
Located Off of Pleasant Street, Natick, Massachusetts

19114.70

Photo No.

11

Date:

10/13/2017

Direction Photo Taken:

Southwest

Description:

View of spalled, deteriorated concrete on downstream side of outlet gate structure. Two 4' x 6' steel slide gates comprise the low-level outlet. Both gates showed no evidence of leakage, however based on diving evaluation conducted as part of 2009 Phase II study, both gates are inoperable and in need of replacement.



Photo No.

12

Date:

10/13/2017

Direction Photo Taken:

West

Description:

View of right training wall from downstream. Note depression/loss of ground behind low training wall on downstream right side of spillway (middle ground of photo).






Client Name: Town of Natick, Massachusetts		Site Location: Charles River Dam at South Natick, Located Off of Pleasant Street, Natick, Massachusetts	Project No. 19114.70
Photo No. 13	Date: 10/13/2017		
Direction Photo Taken: North			
Description: View of missing stones from downstream left training wall segment. Condition appears to be degraded from 2015 inspection.			

Photo No. 14	Date: 10/13/2017	
Direction Photo Taken: South		
Description: Close up of left downstream side of ogee spillway. Note fair to good condition of concrete. Concrete apron beyond ogee poured directly around bedrock outcrop in this area.		




Client Name: Town of Natick, Massachusetts		Site Location: Charles River Dam at South Natick, Located Off of Pleasant Street, Natick, Massachusetts	Project No. 19114.70
Photo No. 15	Date: 10/13/2017		
Direction Photo Taken: North			
Description: View of left side downstream apron and ogee spillway. Note condition of mortared stone training wall near base of ogee at left abutment where loose stones and missing mortar was observed. (See photo 16 for close up).			

Photo No. 16	Date: 10/13/2017	
Direction Photo Taken: North		
Description: Close up of mortared stone masonry wall at left spillway along ogee/abutment contact. Note loss of mortar and loose/displaced stone at bottom. Presence of voids in mortar may contribute to unevenness of paved walkway area above (see photo 17). Wall in similar condition to 2015 inspection. Stones should be reset and wall re-pointed.		



Client Name:

Town of Natick, Massachusetts

Site Location:

Charles River Dam at South Natick,
Located Off of Pleasant Street, Natick, Massachusetts

Project No.

19114.70

Photo No.

17

Date:

10/13/2017

Direction Photo Taken:

East

Description:

View of uneven/cracked paved walkway area behind left spillway abutment wall just downstream of ogee crest.



Photo No.

18

Date:

10/13/2017

Direction Photo Taken:

South

Description:

View of spillway apron downstream of ogee.






APPENDIX C - INSPECTION CHECKLIST

DAM SAFETY INSPECTION CHECKLIST

NAME OF DAM:	<u>Charles River Dam at South Natick</u>	STATE ID #:	<u>4-9-198-1</u>
REGISTERED:	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO	NID ID #:	<u>MA00341</u>
STATE SIZE CLASSIFICATION:	<u>Intermediate</u>	STATE HAZARD CLASSIFICATION:	<u>High</u>
		CHANGE IN HAZARD CLASSIFICATION REQUESTED?:	<u>No</u>
<u>DAM LOCATION INFORMATION</u>			
CITY/TOWN:	<u>Natick</u>	COUNTY:	<u>Middlesex</u>
DAM LOCATION: (street address if known)	<u>South Natick, near Pleasant Street</u>	ALTERNATE DAM NAME:	<u>South Natick Dam</u>
USGS QUAD.:	<u>Framingham</u>	LAT.:	<u>42.271555</u>
		LONG.:	<u>-71.315818</u>
DRAINAGE BASIN:	<u>Charles</u>	RIVER:	<u>Charles River</u>
IMPOUNDMENT NAME(S):	<u>Charles River</u>		
<u>GENERAL DAM INFORMATION</u>			
TYPE OF DAM:	<u>Earth embankment with concrete gravity run-of-river spillway</u>	OVERALL LENGTH (FT):	<u>300</u>
PURPOSE OF DAM:	<u>Recreation</u>	NORMAL POOL STORAGE (ACRE-FT):	<u>220</u>
YEAR BUILT:	<u>~1934 (Rebuilt)</u>	MAXIMUM POOL STORAGE (ACRE-FT):	<u>~500</u>
STRUCTURAL HEIGHT (FT):	<u>15</u>	EL. NORMAL POOL (FT):	<u>110.6</u>
HYDRAULIC HEIGHT (FT):	<u>12</u>	EL. MAXIMUM POOL (FT):	<u>~116.0</u>
<u>FOR INTERNAL MADCR USE ONLY</u>			
FOLLOW-UP INSPECTION REQUIRED:	<input type="checkbox"/> YES <input type="checkbox"/> NO	CONDITIONAL LETTER:	<input type="checkbox"/> YES <input type="checkbox"/> NO

NAME OF DAM: <u>Charles River Dam at South Natick</u>		STATE ID #: <u>4-9-198-1</u>	
INSPECTION DATE: <u>October 13, 2017</u>		NID ID #: <u>MA00341</u>	
<u>INSPECTION SUMMARY</u>			
DATE OF INSPECTION: <u>October 13, 2017</u>		DATE OF PREVIOUS INSPECTION: <u>Last Phase I on 9/9/2015; Phase II in 2009.</u>	
TEMPERATURE/WEATHER: <u>Sunny, 60s-70s</u>		ARMY CORPS PHASE I: <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO If YES, date _____	
CONSULTANT: <u>GZA GeoEnvironmental, Inc.</u>		PREVIOUS DCR PHASE I: <input checked="" type="checkbox"/> YES <input type="checkbox"/> NO If YES, date <u>9/9/2015</u>	
BENCHMARK/DATUM: <u>Chisel square east abutment wall over Charles River - 69.2' from east end (RMI). Elevation = 119.64'</u>			
OVERALL PHYSICAL CONDITION OF DAM: <u>FAIR</u>		DATE OF LAST REHABILITATION: <u>1934</u>	
SPILLWAY CAPACITY: <u>>100% SDF w/ no actions by Caretaker</u>			
EL. POOL DURING INSP.: <u>~ 1 inch over spillway (El. 110.7±)</u>		EL. TAILWATER DURING INSP.: <u>~ 6 inches above streambed at spillway toe (El. 103±)</u>	
<u>PERSONS PRESENT AT INSPECTION</u>			
<u>NAME</u>	<u>TITLE/POSITION</u>	<u>REPRESENTING</u>	
<u>Charles B. Nourse, P.E.</u>	<u>Project Manager</u>	<u>GZA GeoEnvironmental, Inc.</u>	
<u>Maha F. Jarrar</u>	<u>Engineer I</u>	<u>GZA GeoEnvironmental, Inc.</u>	
<u>William McDowell, P.E.</u>	<u>Town Engineer</u>	<u>Town of Natick</u>	
<u>EVALUATION INFORMATION</u>			
Click on box to select E-code		Click on box to select E-code	
E1) TYPE OF DESIGN	<div style="border: 1px solid black; padding: 2px;">4</div>	E8) LOW-LEVEL OUTLET CONDITION	<div style="border: 1px solid black; padding: 2px;">1</div>
E2) LEVEL OF MAINTENANCE	<div style="border: 1px solid black; padding: 2px;">3</div>	E9) SPILLWAY DESIGN FLOOD CAPACITY	<div style="border: 1px solid black; padding: 2px;">5</div>
E3) EMERGENCY ACTION PLAN	<div style="border: 1px solid black; padding: 2px;">5</div>	E10) OVERALL PHYSICAL CONDITION	<div style="border: 1px solid black; padding: 2px;">3</div>
E4) EMBANKMENT SEEPAGE	<div style="border: 1px solid black; padding: 2px;">5</div>	E11) ESTIMATED REPAIR COST	<div style="border: 1px solid black; padding: 2px;">1,270K to 1,570K</div>
E5) EMBANKMENT CONDITION	<div style="border: 1px solid black; padding: 2px;">2</div>	ROADWAY OVER CREST	<div style="border: 1px solid black; padding: 2px;">NO</div>
E6) CONCRETE CONDITION	<div style="border: 1px solid black; padding: 2px;">3</div>	BRIDGE OVER DAM	<div style="border: 1px solid black; padding: 2px;">NO</div>
E7) LOW-LEVEL OUTLET CAPACITY	<div style="border: 1px solid black; padding: 2px;">2</div>	(Pleasant St. Bridge spanning the Charles River is approx. 170' downstream).	
NAME OF INSPECTING ENGINEER: <u>Charles B. Nourse, P.E.</u>		SIGNATURE: 	

NAME OF DAM: <u>Charles River Dam at South Natick</u>		STATE ID #: <u>4-9-198-1</u>	
INSPECTION DATE: <u>October 13, 2017</u>		NID ID #: <u>MA00341</u>	
OWNER: ORGANIZATION	<u>Town of Natick</u>	CARETAKER: ORGANIZATION	<u>Town of Natick</u>
NAME/TITLE	<u>Department of Public Works</u>	NAME/TITLE	<u>Department of Public Works</u>
STREET	<u>75 West Street</u>	STREET	<u>75 West Street</u>
TOWN, STATE, ZIP	<u>Natick, MA 01760</u>	TOWN, STATE, ZIP	<u>Natick, MA 01760</u>
PHONE	<u>508-647-6551</u>	PHONE	<u>508-647-6551</u>
EMERGENCY PH. #	<u>508-647-6550</u>	EMERGENCY PH. #	<u>508-647-6550</u>
FAX	<u>508-647-6560</u>	FAX	<u>508-647-6560</u>
EMAIL	wmcowell@natickma.org	EMAIL	wmcowell@natickma.org
OWNER TYPE	<u>Municipality or Political subdivision</u>		
PRIMARY SPILLWAY TYPE		<u>Concrete gravity ogee weir (slightly curved in upstream direction.</u>	
SPILLWAY LENGTH (FT)	<u>130</u>	SPILLWAY CAPACITY (CFS)	<u>5,870</u>
AUXILIARY SPILLWAY TYPE	<u>N/A</u>	AUX. SPILLWAY CAPACITY (CFS)	<u>N/A</u>
NUMBER OF OUTLETS	<u>2</u>	OUTLET(S) CAPACITY (CFS)	<u>UNKNOWN</u>
TYPE OF OUTLETS	<u>4' x 6' slide gates</u>	TOTAL DISCHARGE CAPACITY (CFS)	<u>5,870</u>
DRAINAGE AREA (SQ MI)	<u>165±</u>	SPILLWAY DESIGN FLOOD (PERIOD/CFS)	<u>500 YR. / 5,000 (2009 IDA)</u>
HAS DAM BEEN BREACHED OR OVERTOPPED <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO IF YES, PROVIDE DATE(S) _____			
FISH LADDER (LIST TYPE IF PRESENT)		<u>Yes; concrete Denil type; no longer operational.</u>	
DOES CREST SUPPORT PUBLIC ROAD? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		IF YES, ROAD NAME: _____	
PUBLIC BRIDGE WITHIN 50' OF DAM? <input type="checkbox"/> YES <input checked="" type="checkbox"/> NO		IF YES, ROAD/BRIDGE NAME: <u>Pleasant Street Bridge ~ 170' downstream.</u>	
		MHD BRIDGE NO. (IF APPLICABLE) _____	

NAME OF DAM: Charles River Dam at South NatickSTATE ID #: 4-9-198-1INSPECTION DATE: October 13, 2017NID ID #: MA00341**EMBANKMENT (CREST)**

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	1. SURFACE TYPE	Earth with wood chip footpath.		X	
	2. SURFACE CRACKING	None observed		X	
	3. SINKHOLES, ANIMAL BURROWS	None observed		X	
	4. VERTICAL ALIGNMENT (DEPRESSIONS)	Uneven surface		X	
	5. HORIZONTAL ALIGNMENT	Adequate	X		
	6. RUTS AND/OR PUDDLES	Numerous tree roots make for an irregular surface. Minor rutting/eroded zones observed.			X
	7. VEGETATION (PRESENCE/CONDITION)	Mature trees up to 30" Dia., high shrubs and grass; all should be removed (including root systems).			X
	8. ABUTMENT CONTACT	Good. Natural river channel/wooded area on right. Landscaped park area at left.	X		

ADDITIONAL COMMENTS: 1. Earth embankment (approximately 300-feet-long) present only on right side of spillway. Left abutment consists of stone masonry wall at left edge of spillway, the backside of which abuts an open, grassed park area.

2. Presence of heavy vegetative overgrowth, particularly along the upstream and downstream edges of the crest, obscured close inspection.

NAME OF DAM: <u>Charles River Dam at South Natick</u>		STATE ID #: <u>4-9-198-1</u>			
INSPECTION DATE: <u>October 13, 2017</u>		NID ID #: <u>MA00341</u>			
EMBANKMENT (D/S SLOPE)					
AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S SLOPE	1. WET AREAS (NO FLOW)	At former sluiceway, standing water and very minor leakage from plugged outlet (1).		X	
	2. SEEPAGE	Very minor leakage at blocked stone masonry sluiceway near right abutment of dam.		X	
	3. SLIDE, SLOUGH, SCARP	None observed.	X		
	4. EMB.-ABUTMENT CONTACT	Good.	X		
	5. SINKHOLE/ANIMAL BURROWS	The presence of heavy overgrowth obscured close inspection. (2)			X
	6. EROSION	Some wear and bare surface near river due to pedestrian foot traffic.		X	
	7. UNUSUAL MOVEMENT	None observed.	X		
	8. VEGETATION (PRESENCE/CONDITION)	Mature trees, high dense posion ive and some grass; trees, shrubbery and their root systems should be removed and the downstream slope area re-graded. (3)			X
ADDITIONAL COMMENTS: 1. Clear leakage less than ~1 gallons per minute observed. Note, during heavy rainfall/flood events backwater from river flow pools against and immediately downstream along a significant portion of the earthen embankment toe portion. 2. A few small (2"-dia.) rodent holes were observed just downstream of vertical stone wall near the right spillway abutment. It also appears that rodents are active within the wall as evidenced by holes and loss of soil along wall base. 3. Significant areas of the embankment are uneven/undulating. It is recommended that low/uneven areas be filled and the entire embankment be re-graded so that the area is made even, as per the 1934 design drawing.					

NAME OF DAM: <u>Charles River Dam at South Natick</u>		STATE ID #: <u>4-9-198-1</u>			
INSPECTION DATE: <u>October 13, 2017</u>		NID ID #: <u>MA00341</u>			
EMBANKMENT (U/S SLOPE)					
AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S SLOPE	1. SLIDE, SLOUGH, SCARP	Conditions were obscured by heavy vegetative growth. Minor to moderate scarps observed during previous inspection.			X
	2. SLOPE PROTECTION TYPE AND COND.	Remnants of stone riprap, mostly sediment-filled with vegetation. New riprap is recommended.			X
	3. SINKHOLE/ANIMAL BURROWS	None observed (1).		X	
	4. EMB.-ABUTMENT CONTACT	Adequate.		X	
	5. EROSION	Some minor to moderate erosion at the waterline. (2)			X
	6. UNUSUAL MOVEMENT	None observed.	X		
	7. VEGETATION (PRESENCE/CONDITION)	Mature trees and brush throughout; should be removed.			X
ADDITIONAL COMMENTS: <u>1. Presence of heavy vegetative overgrowth along entire length of upstream slope precluded close inspection.</u> <u>2. Some erosion likely caused by site visitors who fish from the upstream slope.</u> 					

NAME OF DAM: Charles River Dam at South NatickSTATE ID #: 4-9-198-1INSPECTION DATE: October 13, 2017NID ID #: MA00341**INSTRUMENTATION**

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
INSTR.	1. PIEZOMETERS	One open standpipe piezometer was installed as part of GZA's 2009 Phase II study.		X	
	2. OBSERVATION WELLS	Three observation wells were installed as part of GZA's 2009 Phase II study.		X	
	3. STAFF GAGE AND RECORDER	None observed.	X		
	4. WEIRS	None observed.	X		
	5. INCLINOMETERS	None observed.	X		
	6. SURVEY MONUMENTS	None observed.	X		
	7. DRAINS	None observed.	X		
	8. FREQUENCY OF READINGS	Not regularly taken other than at every two-year inspection.		X	
	9. LOCATION OF READINGS	Readings taken during inspection are listed in the inspection checklist below.		X	

ADDITIONAL COMMENTS: 1. Open standpipe piezometer is within GZ-2. Observation well above piezometer in GZ-2.; one each also in GZ-1 and GZ-3.
Refer to the field sketch for approximate plan locations.

2. The following depth to water readings (feet below ground surface) were obtained during the inspection visit: GZ-1 = 6.2'
GZ-2 (piezometer) = 10.4', GZ-2 (observation well) = 12.8' and GZ-3 = 9.3'.

NAME OF DAM: Charles River Dam at South NatickSTATE ID #: 4-9-198-1INSPECTION DATE: October 13, 2017NID ID #: MA00341**DOWNSTREAM MASONRY SPILLWAY TRAINING WALLS**

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S WALLS	1. WALL TYPE	Mortared stone masonry along right and left sides from spillway down to the (1)			X
	2. WALL ALIGNMENT	Minor to moderate loss of ground behind length of low wall along the right side. (2)			X
	3. WALL CONDITION	Fair. Some missing stones and mortar particularly at waterline. (3)			X
	4. HEIGHT: TOP OF WALL TO MUDLINE	min: max: avg: ~ 4 to 5 feet		X	
	5. SEEPAGE OR LEAKAGE	None observed.		X	
	6. ABUTMENT CONTACT	Adequate.		X	
	7. EROSION/SINKHOLES BEHIND WALL	Aforementioned loss of ground behind portions of wall, likely due to past (4)			X
	8. ANIMAL BURROWS	None observed.		X	
	9. UNUSUAL MOVEMENT	Wall portions particularly low wall on right side lean toward the River.			X
	10. WET AREAS AT TOE OF WALL	Base of walls are submerged as they define the discharge channel geometry.	X		

ADDITIONAL COMMENTS: 1. Pleasant Street road crossing some 170 feet downstream.

2. Left side generally even with localized loss of ground and missing stones - alignment generally good.

3. Right wall in generally similar condition to 2015 inspection. Localized displacement of stones at left training wall. Some erosion at back of wall due to pedestrian foot traffic, about 20 feet downstream of high/low transition. Loss of stone and loss of ground at some locations between 6 and 12 inches deep. Approximately 60 feet downstream of high/low transition, a 1/2 to 1 inch wide crack at training wall with 12 inch square by 6 inch deep depression.

4. flooding during which water level in discharge channel overtops training walls. No significant change since last inspection.

NAME OF DAM: Charles River Dam at South NatickSTATE ID #: 4-9-198-1INSPECTION DATE: October 13, 2017NID ID #: MA00341**UPSTREAM MASONRY SPILLWAY TRAINING WALLS**

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S WALLS	1. WALL TYPE	Mortared stone masonry at right side of spillway in good condition. (1)			X
	2. WALL ALIGNMENT	Right side good; Left side slightly uneven due to presence of past tree growth through stone.			X
	3. WALL CONDITION	Right side good; left side at spillway fair with some deteriorated mortar, unevenness and tree presence; low training portion upstream of spillway fair to poor (1).			X
	4. HEIGHT: TOP OF WALL TO MUDLINE	min: 2.5 feet max: 4.5 feet avg: 3.5 feet ±		X	
	5. ABUTMENT CONTACT	Adequate.	X		
	6. EROSION/SINKHOLES BEHIND WALL	None observed on right side; minor loss of ground on backside of low training wall portion along left side upstream of spillway (2).			X
	7. ANIMAL BURROWS	None observed.		X	
	8. UNUSUAL MOVEMENT	Low (cast-in-place concrete) training wall upstream of left spillway spalled, cracked, uneven and partially leaning into the river. In need of repairs.			X
	9. VEGETATION	Small trees and brush growing from masonry wall just upstream of spillway.			

ADDITIONAL COMMENTS: 1. Mortared stone masonry at left side of spillway fair with minor to moderate cracking, loose stone/mortar observed. First 40' top of low left wall section separated from curb up to 4.5". Low training walls upstream of left spillway training wall consists of cracked, spalled, mis-aligned sections of deteriorated cast-in-place concrete. Segment (approximately 100 feet) from spillway upstream leaning toward the river moderately to heavily cracked/deteriorating/displaced and in need of repair.

2. Presence of depressions and unevenness in paved walkway behind wall section at spillway indicative of possible underlying minor erosion issue/loss of ground behind/through wall in this area. Concrete wall deteriorated/eroded near waterline.

NAME OF DAM: Charles River Dam at South NatickSTATE ID #: 4-9-198-1INSPECTION DATE: October 13, 2017NID ID #: MA00341**DOWNSTREAM AREA**

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S AREA	1. ABUTMENT LEAKAGE	None observed.	X		
	2. FOUNDATION SEEPAGE	None observed. (1)	X		
	3. SLIDE, SLOUGH, SCARP	None observed.	X		
	4. WEIRS	None observed.	X		
	5. DRAINAGE SYSTEM	None observed.	X		
	6. INSTRUMENTATION	None observed.	X		
	7. VEGETATION	Trees and brush.		X	
	8. ACCESSIBILITY	Located in suburban South Natick.	X		
		Portions of left and right abutment used as parks.			
	9. DOWNSTREAM HAZARD DESCRIPTION	High Hazard. Pleasant Street downstream and residential development along Water Street.	X		
	10. DATE OF LAST EAP UPDATE	Updated by GZA in 2012.		X	

ADDITIONAL COMMENTS: 1. Downstream area beyond spillway channel is normally under water at this run-of-the-river dam spillway. Geometry of downstream channel is such that water, particularly during periods of high flow, pools along the downstream area and up over the toe of the earthen embankment portion. This backwater condition may contribute to the unevenness of the downstream embankment.

NAME OF DAM: <u>Charles River Dam at South Natick</u>		STATE ID #: <u>4-9-198-1</u>
INSPECTION DATE: <u>October 13, 2017</u>		NID ID #: <u>MA00341</u>
MISCELLANEOUS		
AREA INSPECTED	CONDITION	OBSERVATIONS
MISC.	1. RESERVOIR DEPTH (AVG)	Impoundment is the Charles River; depth varies but generally presumed to be less than 10 feet deep.
	2. RESERVOIR SHORELINE	Wooded on both sides with some residential development.
	3. RESERVOIR SLOPES	Moderate.
	4. ACCESS ROADS	None directly to dam. Dam serves also as a park. Suburban streets are nearby.
	5. SECURITY DEVICES	None. Railing at both spillway abutments (1), (3).
	6. VANDALISM OR TRESPASS	<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO WHAT:
	7. AVAILABILITY OF PLANS	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO DATE: Limited - See note 2.
	8. AVAILABILITY OF DESIGN CALCS	<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO DATE:
	9. AVAILABILITY OF EAP/LAST UPDATE	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO DATE: Updated by GZA in 2012.
	10. AVAILABILITY OF O&M MANUAL	<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO DATE:
	11. CARETAKER/OWNER AVAILABLE	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO DATE: Present during portion of inspection.
	12. CONFINED SPACE ENTRY REQUIRED	<input type="checkbox"/> YES <input checked="" type="checkbox"/> NO PURPOSE:
ADDITIONAL COMMENTS: <u>1. Iron railing on top of right upstream training wall should be extended to the upstream end to provide additional safety from River/spillway portion below. Portion of railings near left abutment/ spillway are bent/damaged and should be replaced.</u>		
<u>2. GZA reviewed a limited number of design drawings (circa 1934) during our 2009 Phase II evaluation.</u>		
<u>3. No safety signage present regarding warning to boats/canoes approaching spillway. Signage and/or floating booms are recommended.</u>		

NAME OF DAM: <u>Charles River Dam at South Natick</u>		STATE ID #: <u>4-9-198-1</u>			
INSPECTION DATE: <u>October 13, 2017</u>		NID ID #: <u>MA00341</u>			
PRIMARY SPILLWAY					
AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE	Uncontrolled, arch (in upstream direction) shaped concrete weir.	X		
	WEIR TYPE	Ogee style.	X		
	SPILLWAY CONDITION	Diving inspection of upstream face conducted in 2009. Condition of (1)		X	
	TRAINING WALLS	Mortared stone masonry, generally in fair condition. (2)			X
	SPILLWAY CONTROLS AND CONDITION	Uncontrolled.	X		
	UNUSUAL MOVEMENT	None observed at spillway, see notes this and other sheets for upstream and downstream training wall deficiencies.			X
	APPROACH AREA	River generally clear.		X	
	DISCHARGE AREA	River. Heavily vegetated island located in middle of river/discharge channel.		X	
	DEBRIS	Some vegetation.		X	
	WATER LEVEL AT TIME OF INSPECTION	Approximately 1 inch above crest of spillway.	X		
<p>ADDITIONAL COMMENTS: 1. concrete above the mudline was satisfactory. Significant amount of sediment, tree waste and miscellaneous debris submerged beneath the waterline on upstream side of weir. Flow in river only 1 inch above spillway crest allowed for close view of spillway conditions during this inspection. Condition of concrete ogee section fair to good. Irregularity in flow immediately downstream at left side noted in past inspections confirmed as a bedrock outcrop in 2015 inspection. Concrete apron present along remainder of base.</p> <p>2. Some deterioration at waterline on left and right downstream sides with occasional loose/missing stones and cracked/missing mortar. Low stone walls on right and left sides missing stones in localized areas. Stone loss along contact with downstream side of spillway on left side somewhat more prevalent than 2013 inspection. Low stone wall on right side also generally has a slight lean toward the river with minor to moderate loss of ground immediately behind.</p>					

NAME OF DAM: Charles River Dam at South Natick

STATE ID #: 4-9-198-1

INSPECTION DATE: October 13, 2017

NID ID #: MA00341

AUXILIARY SPILLWAY

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
SPILLWAY	SPILLWAY TYPE				
	WEIR TYPE				
	SPILLWAY CONDITION				
	TRAINING WALLS	N/A FOR THIS DAM			
	SPILLWAY CONTROLS AND CONDITION				
	UNUSUAL MOVEMENT				
	APPROACH AREA				
	DISCHARGE AREA				
	DEBRIS				
	WATER LEVEL AT TIME OF INSPECTION				

ADDITIONAL COMMENTS: _____

NAME OF DAM: Charles River Dam at South NatickSTATE ID #: 4-9-198-1INSPECTION DATE: October 13, 2017NID ID #: MA00341**OUTLET WORKS**

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
OUTLET WORKS	TYPE	Two 4' by 6' steel slide gates at right side of spillway.			X
	INTAKE STRUCTURE	At right spillway abutment. Concrete structure in fair condition with some spalls. (1)			X
	TRASHRACK	None observed.	X		
	PRIMARY CLOSURE	Inspection of gate in Oct. 2008 yielded the following information in note (2) below.			X
	SECONDARY CLOSURE	None observed.	X		
	CONDUIT	None observed.	X		
	OUTLET STRUCTURE/HEADWALL	Same as intake structure on downstream side.			X
	EROSION ALONG TOE OF DAM	None observed.		X	
	SEEPAGE/LEAKAGE	No leakage through gates at time of this inspection. Evidence of past leakage in (3)			X
	DEBRIS/BLOCKAGE	None observed.		X	
	UNUSUAL MOVEMENT	None observed.		X	
	DOWNSTREAM AREA	Discharges to river channel.	X		
	MISCELLANEOUS	Rodney Hunt spigot-type slide gates (circa 1934) in need of replacement.			X

ADDITIONAL COMMENTS: 1. Gate guides on the upstream side show rusting and are in fair/poor condition. Gate operators painted and in satisfactory condition. No wheel/crank arm for operators is present. Town has homemade crank wheel at DPW headquarters.

2. Brass stems on gates appeared to be in good condition. Right gate raised slightly in 2008 via portable crank arm on right operator to confirm stem operability. Underwater diving inspection undertaken as part of 2009 Phase II indicated that slide grooves, and gate hardware including the brass compression wedges were significantly deteriorated. Gates deemed inoperable and in need of replacement.

3. in the form of wetness, staining and/or efflorescence. Spalling and erosion of concrete wall near fish ladder.

NAME OF DAM: Charles River Dam at South Natick

STATE ID #: 4-9-198-1

INSPECTION DATE: October 13, 2017

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CONCRETE/MASONRY DAMS

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
GENERAL	TYPE				
	AVAILABILITY OF PLANS				
	AVAILABILITY OF DESIGN CALCS	N/A FOR THIS DAM			
	PIEZOMETERS				
	OBSERVATION WELLS				
	INCLINOMETERS				
	SEEPAGE GALLERY				
	UNUSUAL MOVEMENT				

ADDITIONAL COMMENTS: _____

NAME OF DAM: Charles River Dam at South Natick

STATE ID #: 4-9-198-1

INSPECTION DATE: October 13, 2017

NID ID #: MA00341

CONCRETE/MASONRY DAMS (CREST)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
CREST	TYPE	N/A FOR THIS DAM			
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	HORIZONTAL ALIGNMENT				
	VERTICAL ALIGNMENT				

ADDITIONAL COMMENTS: _____

NAME OF DAM: Charles River Dam at South Natick

STATE ID #: 4-9-198-1

INSPECTION DATE: October 13, 2017

NID ID #: MA00341

CONCRETE/MASONRY DAMS (DOWNSTREAM FACE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
D/S FACE	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT				
	ABUTMENT CONTACT				
	LEAKAGE				

**N/A FOR
THIS DAM**

ADDITIONAL COMMENTS: _____

NAME OF DAM: Charles River Dam at South Natick

STATE ID #: 4-9-198-1

INSPECTION DATE: October 13, 2017

NID ID #: MA00341

CONCRETE/MASONRY DAMS (UPSTREAM FACE)

AREA INSPECTED	CONDITION	OBSERVATIONS	NO ACTION	MONITOR	REPAIR
U/S FACE	TYPE				
	SURFACE CONDITIONS				
	CONDITIONS OF JOINTS				
	UNUSUAL MOVEMENT	N/A FOR THIS DAM			
	ABUTMENT CONTACTS				

ADDITIONAL COMMENTS: _____



APPENDIX D - PREVIOUS REPORTS AND REFERENCES



PREVIOUS REPORTS AND REFERENCES

The following is a list of reports, drawings and photos that were located during the file review, or were referenced in previous reports.

1. Charles River Dam at South Natick Phase II Dam Safety Engineering Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, October 2009.
2. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, September 9, 2015.
3. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, May 23, 2013.
4. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, June 20, 2011.
5. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, October 2 and 8, 2008.
6. Charles River Dam at South Natick Inspection/Evaluation Report, GZA GeoEnvironmental, Inc. on behalf of the Town of Natick, Natick, Massachusetts, September 18, 2006.
7. Series of six drawings by Fay, Spofford & Thorndike, Inc. (FST) depicting proposed major reconstruction of the existing dam at Charles River in Natick, dated 1933 to 1934 obtained from FST archives.
8. Series of eleven photographs supposedly depicting conditions at the dam pre circa 1934 obtained from the Town of Natick Historical Society.
9. Series of ten photographs supposedly depicting conditions at the dam post circa 1934 obtained from the Town of Natick Historical Society.
10. Charles River Dam at South Natick Inspection/Evaluation Report, Weston & Sampson Engineers Inc. on behalf of the DCR Office of Dam Safety (formerly known as the Department of Environmental Management), Natick, Massachusetts, May 13, 1998.
11. Charles River Dam at South Natick Inspection/Evaluation Report, Cleverdon, Varney, and Pike, Inc. on behalf of the DCR Office of Dam Safety (formerly known as the Department of Environmental Management), Natick, Massachusetts, October 16, 1987.

The following references were utilized during the preparation of this report and the development of the recommendations presented herein.

1. Commonwealth of Massachusetts Regulations, 302 CMR 10.00 – Dam Safety, Effective 11/4/05.



APPENDIX E - DEFINITIONS



COMMON DAM SAFETY DEFINITIONS

For a comprehensive list of dam engineering terminology and definitions refer to 302 CMR10.00 Dam Safety, or other reference published by FERC, Dept. of the Interior Bureau of Reclamation, or FEMA. Please note should discrepancies between definitions exist, those definitions included within 302 CMR 10.00 govern for dams located within the Commonwealth of Massachusetts.

Orientation

Upstream – Shall mean the side of the dam that borders the impoundment.

Downstream – Shall mean the high side of the dam, the side opposite the upstream side.

Right – Shall mean the area to the right when looking in the downstream direction.

Left – Shall mean the area to the left when looking in the downstream direction.

Dam Components

Dam – Shall mean any artificial barrier, including appurtenant works, which impounds or diverts water.

Embankment – Shall mean the fill material, usually earth or rock, placed with sloping sides, such that it forms a permanent barrier that impounds water.

Crest – Shall mean the top of the dam, usually provides a road or path across the dam.

Abutment – Shall mean that part of a valley side against which a dam is constructed. An artificial abutment is sometimes constructed as a concrete gravity section, to take the thrust of an arch dam where there is no suitable natural abutment.

Appurtenant Works – Shall mean structures, either in dams or separate therefrom, including but not be limited to, spillways; reservoirs and their rims; low-level outlet works; and water conduits including tunnels, pipelines, or penstocks, either through the dams or their abutments.

Spillway – Shall mean a structure over or through which water flows are discharged. If the flow is controlled by gates or boards, it is a controlled spillway; if the fixed elevation of the spillway crest controls the level of the impoundment, it is an uncontrolled spillway.

Size Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

Large – structure with a height greater than 40 feet or a storage capacity greater than 1,000 acre-ft.

Intermediate – structure with a height between 15 and 40 feet or a storage capacity of 50 to 1,000 acre-ft.

Small – structure with a height between 6 and 15 feet and a storage capacity of 15 to 50 acre-ft.

Non-Jurisdictional – structure less than 6 feet in height or having a storage capacity of less than 15 acre-ft.

Hazard Classification

(as listed in Commonwealth of Massachusetts, 302 CMR 10.00 *Dam Safety*)

High Hazard (Class I) – Shall mean dams located where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important public utilities, main highway(s) or railroad(s).



Significant Hazard (Class II) – Shall mean dams located where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause the interruption of the use or service of relatively important facilities.

Low Hazard (Class III) – Dams located where failure may cause minimal property damage to others. Loss of life is not expected.

General

EAP – Emergency Action Plan – Shall mean a predetermined (and properly documented) plan of action to be taken to reduce the potential for property damage and/or loss of life in an area affected by an impending dam failure.

O&M Manual – Operations and Maintenance Manual; Document identifying routine maintenance and operational procedures under normal and storm conditions.

Normal Pool – Shall mean the elevation of the impoundment during normal operating conditions.

Acre-foot – Shall mean a unit of volumetric measure that would cover one acre to a depth of one foot. It is equal to 43,560 cubic feet. One million U.S. gallons = 3.068 acre feet.

Height of Dam (Structural Height) – Shall mean the vertical distance from the lowest portion of the natural ground, including any stream channel, along the downstream toe of the dam to the lowest point on the crest of the dam.

Hydraulic Height – means the height to which water rises behind a dam and the difference between the lowest point in the original streambed at the axis of the dam and the maximum controllable water surface.

Maximum Water Storage Elevation – means the maximum elevation of water surface which can be contained by the dam without overtopping the embankment section.

Spillway Design Flood (SDF) – Shall mean the flood used in the design of a dam and its appurtenant works particularly for sizing the spillway and outlet works, and for determining maximum temporary storage and height of dam requirements.

Maximum Storage Capacity – The volume of water contained in the impoundment at maximum water storage elevation.

Normal Storage Capacity – The volume of water contained in the impoundment at normal water storage elevation.

Condition Rating

Unsafe – Major structural*, operational, and maintenance deficiencies exist under normal operating conditions.

Poor – Significant structural*, operation and maintenance deficiencies are clearly recognized for normal loading conditions.

Fair – Significant operational and maintenance deficiencies, no structural deficiencies. Potential deficiencies exist under unusual loading conditions that may realistically occur. Can be used when uncertainties exist as to critical parameters.

Satisfactory – Minor operational and maintenance deficiencies. Infrequent hydrologic events would probably result in deficiencies.

Good – No existing or potential deficiencies recognized. Safe performance is expected under all loading including SDF.

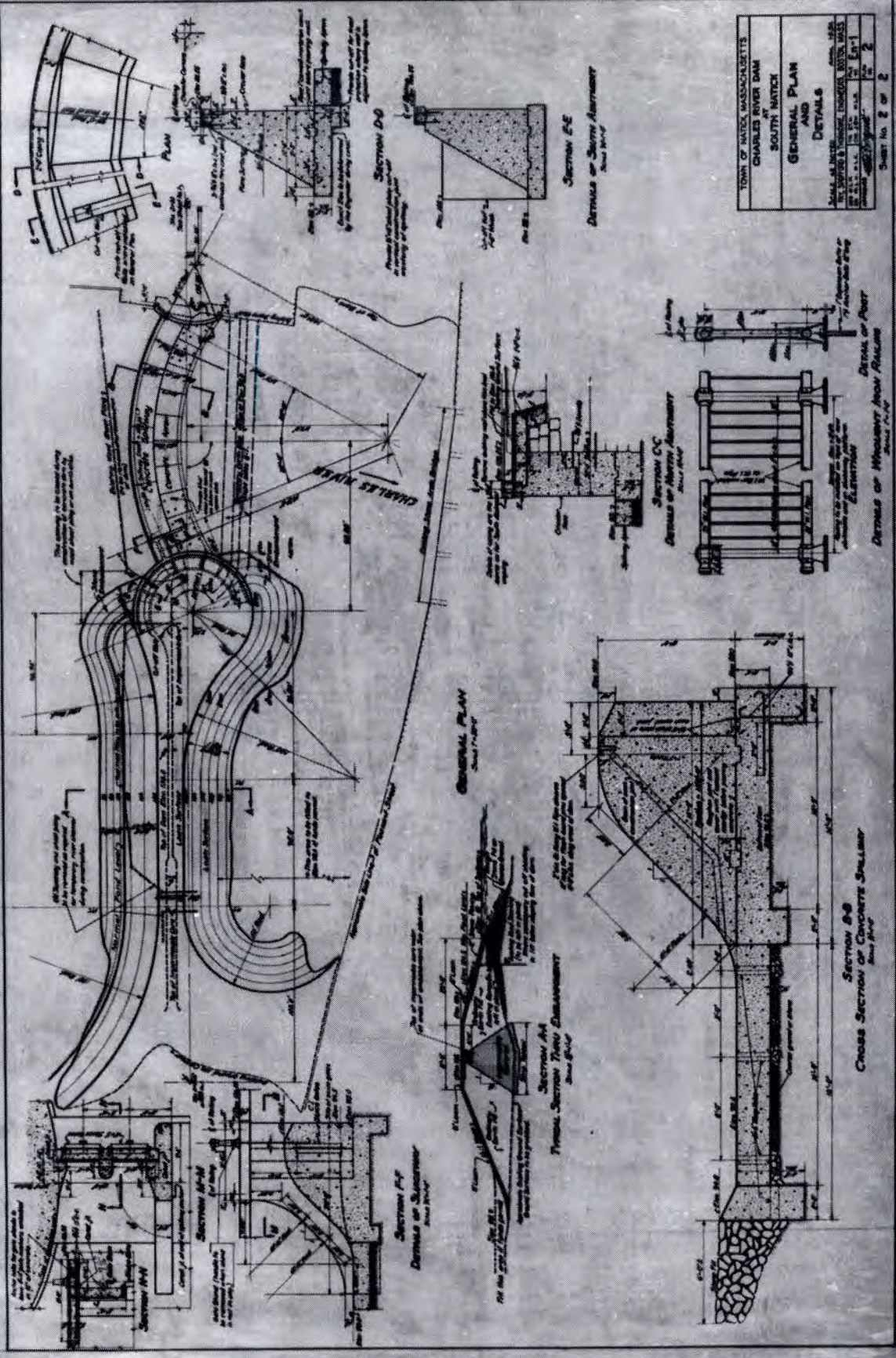


* Structural deficiencies include but are not limited to the following:

- Excessive uncontrolled seepage (e.g., upwelling of water, evidence of fines movement, flowing water, erosion, etc.)
- Missing riprap with resulting erosion of slope
- Sinkholes, particularly behind retaining walls and above outlet pipes, possibly indicating loss of soil due to piping, rather than animal burrows
- Excessive vegetation and tree growth, particularly if it obscures features of the dam and the dam cannot be fully inspected
- Deterioration of concrete structures (e.g., exposed rebar, tilted walls, large cracks with or without seepage, excessive spalling, etc.)
- Inoperable outlets (gates and valves that have not been operated for many years or are broken)

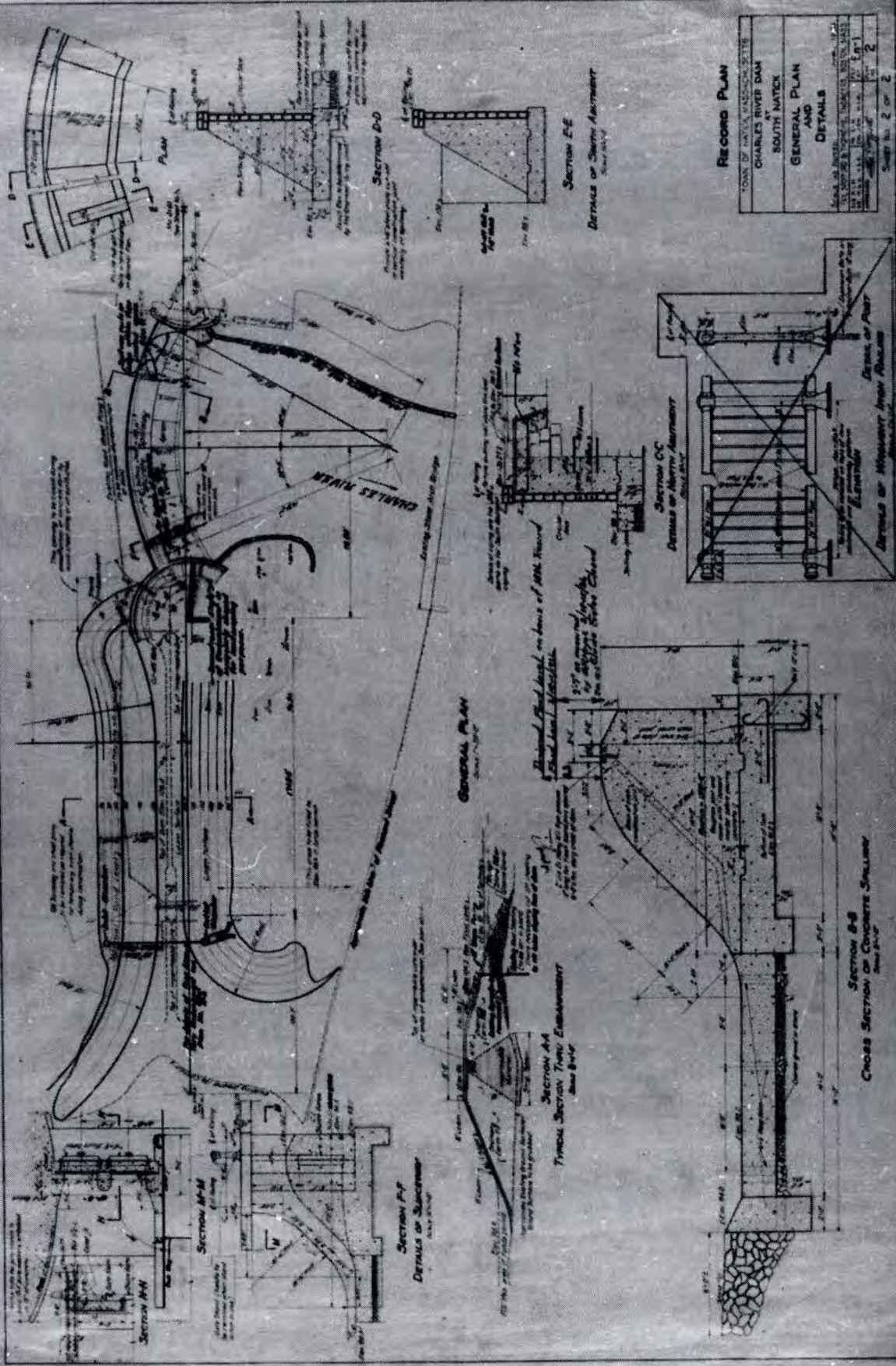


APPENDIX F - HISTORIC DOCUMENTATION



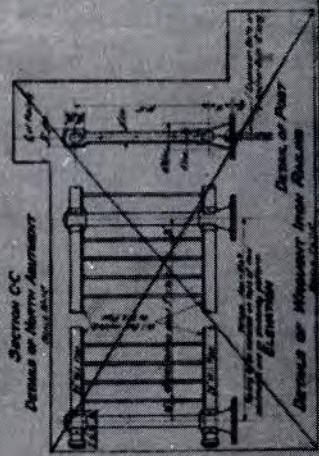
TOWN OF NANTUCKET, MASSACHUSETTS	
CHARLES RIVER DAM	
SOUTH MATCH	
GENERAL PLAN	
AND	
DETAILS	
Scale of Plan	1" = 100'
Scale of Section	1" = 10'
Scale of Detail	1" = 10'
Scale of Elevation	1" = 10'
Scale of Foundation	1" = 10'
Scale of Structure	1" = 10'
Scale of Equipment	1" = 10'
Scale of Finish	1" = 10'
Scale of Detail	1" = 10'
Scale of Elevation	1" = 10'
Scale of Foundation	1" = 10'
Scale of Structure	1" = 10'
Scale of Equipment	1" = 10'
Scale of Finish	1" = 10'

Sheet No. 2 of 2



RECORD PLAN	
TOWN OF NANTUCKET, MASS.	DATE: 1911
CHARLES RIVER DAM	BY: [Signature]
SOUTH MATCH	CHECKED BY: [Signature]
GENERAL PLAN	SCALE: 1" = 100'
AND	
DETAILS	
Sheet No. 2 of 2	

SECTION B-B
CROSS SECTION OF CONCRETE SPILLWAY



SECTION E-E
DETAILS OF Spillway Abutment

SECTION D-D

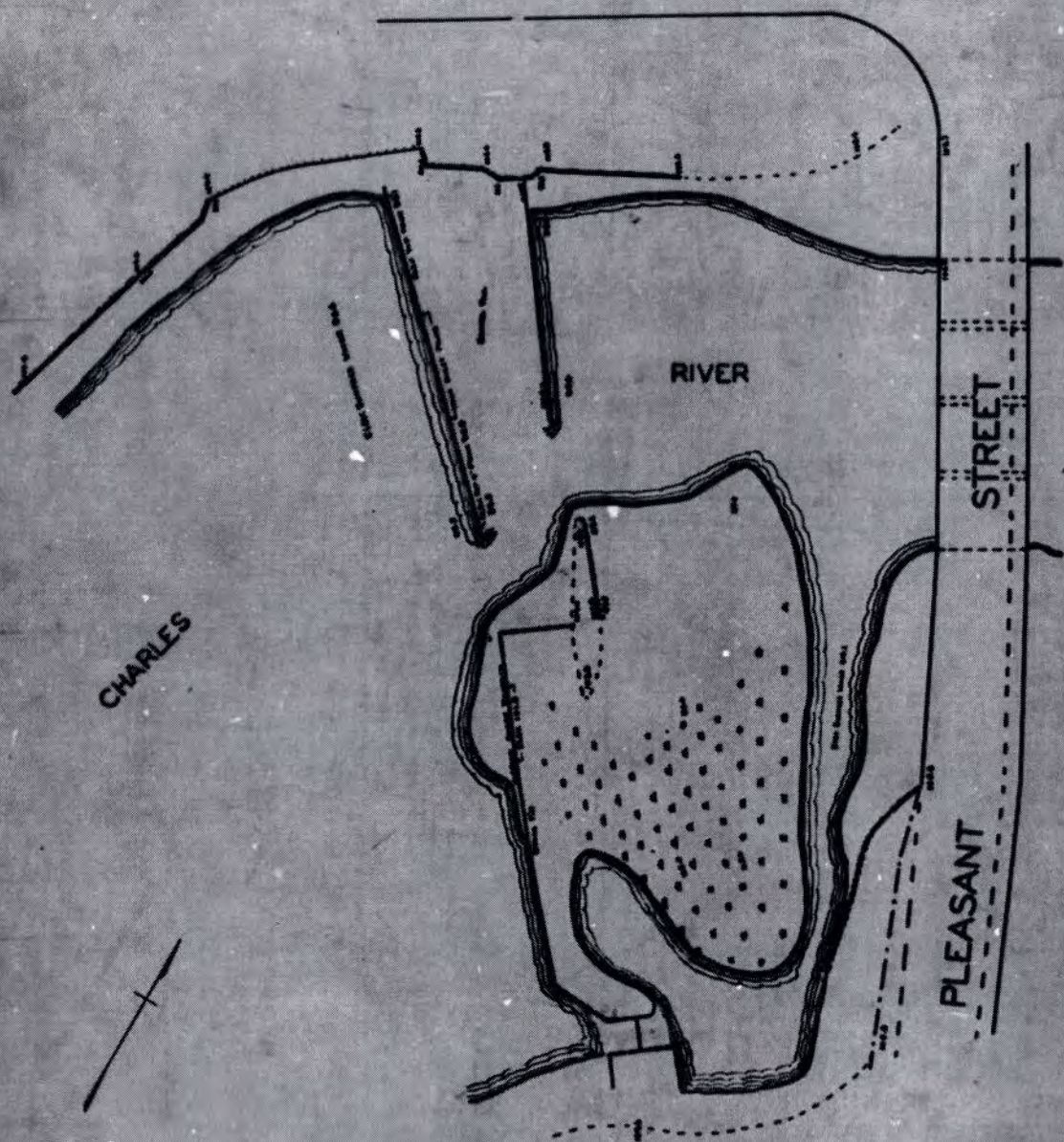
SECTION F-F
DETAILS OF Spillway

SECTION A-A
TYPICAL SECTION THRU EMBANKMENT

SECTION M-M

SECTION H-H

GENERAL PLAN



PLAN OF
CHARLES RIVER DAM
NATICK MASS.
SCALE 1"=50' NOV 1903